CHAPMAN LAKES ENGINEERING FEASIBILITY STUDY

KOSCIUSKO COUNTY, INDIANA

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Prepared For:
Chapman Lakes Conservation Association
c/o Dan Lee, President
P.O. Box 776
Warsaw, Indiana 46581-0776
(574) 267-7666

Prepared By:
J.F. New & Associates, Inc.
c/o John B. Richardson
708 Roosevelt Road
Walkerton, Indiana 46574
(574) 586-3400

EXECUTIVE SUMMARY

The Chapman Lake Conservation Association (CLCA) received an Indiana Department of Natural Resources (IDNR) Lake and River Enhancement (LARE) grant to complete an engineering feasibility study on lake improvement projects identified during the Chapman Lakes Diagnostic Study in 2001. The goal of the feasibility study was to analyze potential project sites where sources of pollution may exist, suggest projects that may address pollution, and examine the feasibility of project design and construction. To be deemed feasible, a project and project sites need to be acceptable to property owners, receive regulatory agency support, be physically constructible, and be environmentally and socially justifiable.

This study pursued the feasibility of three projects within the Chapman Lakes Watershed: bank and channel stabilization of Crooked Creek at Big Chapman Lake, bank and channel stabilization of Arrowhead Drain at Little Chapman Lake, and retrofitting of storm drains that conduct runoff to Big Chapman Lake. The order of the above projects is the order in which the projects will be pursued for design and construction funding in the future. The Crooked Creek project was estimated to cost $96,438 with design-build funding available from the IDNR LARE Program in 2002 and CLCA 25% cost-share. The cost estimate for the Arrowhead Drain stabilization project was $67,725. Storm drains could potentially be retrofitted with a combination of local funding and federal grants available through county governments like 205(j) or 319 grants at an estimated cost of $46,100-$52,100.

It is recommended that the Chapman Lakes Foundation complete work on Crooked Creek in 2003. The Foundation should pursue a LARE grant for the proposed work on Arrowhead Drain in 2003 with potential for construction in 2004. At the same time small grants or local funding should be pursued for five of the prioritized storm drains.

ACKNOWLEDGMENTS

This feasibility study was performed with funding from the Indiana Department of Natural Resources Division of Soil Conservation and the Chapman Lakes Conservation Association. J.F. New & Associates, Inc. documented available historical information, assessed project feasibility and environmental impact, and forwarded probability opinions of cost for three of the projects identified during the 2001 Chapman Lakes Diagnostic Study. Dan Lee and Bill Curts of the Chapman Lakes Conservation Association provided initiative and assistance in getting this study completed. Special thanks are due to Chapman Lake property owners Greg Hall and Dale and Sheryl Conley for their assistance. Crooked Creek Development, L.L.C. has avidly supported the projects both morally and financially. Bob Sanders and the Kosciusko County clerk's office provided property owner information for the project areas. Thanks to the Chapman Lake Conservation Association members and the Chapman Lakes Foundation for support. Authors of this report include Cornelia Sawatzky, John Richardson, Marianne Giolitto and Sara Peel with J.F. New & Associates, Inc.

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1.0 INTRODUCTION

1.1 BACKGROUND

Chapman Lake property owners and lake users have recognized that lake quality is directly connected to activities along the shoreline and in the watershed. Noted lake and lake water quality concerns include: increasing quantities of aquatic plants, increasing sediment bar deposition at the mouths of tributaries and in bays, and poor water clarity. In 2000, the Chapman Lakes Conservation Club (CLCC) received a grant from the Indiana Department of Natural Resources (IDNR) Lake and River Enhancement (LARE) Program to conduct a lake and watershed diagnostic study in order to document existing conditions in the Chapman Lakes and their watershed and to diagnose potential pollutant sources to the lake. J.F. New & Associates, Inc. (JFNew) conducted the 2001 Chapman Lake Diagnostic Study. According to the study, water quality in Big Chapman Lake is good, but concern for worsening conditions is warranted. Little Chapman Lake is eutrophic with rooted plant problem areas and poor transparency. Phosphorus modeling suggests than the majority of phosphorus loading to both lakes originates from external sources in the watershed. The study recommended addressing watershed-level issues before attempting in-lake treatment. These watershed-level issues included: bank and channel erosion along Crooked Creek and Arrowhead Drain and pollutant introduction via direct storm drainpipes. In 2001, the Chapman Lakes Conservation Association (CLCA) received a feasibility study grant to follow up on recommendations from the diagnostic study. The purpose of the current study is to determine design and construction feasibility for recommended projects in the Chapman Lakes Watershed.

1.2 SCOPE OF STUDY

The scope of the study included Big and Little Chapman Lakes and their 4,567-acre (1,849-ha) watershed in Kosciusko County. This feasibility study specifically targeted the Crooked Creek and Arrowhead Drain Subwatershed areas for project implementation and recognized the need to address storm water runoff issues from streets and residential areas. JFNew conducted field surveys in the Crooked Creek and Arrowhead Drain Subwatersheds in order to identify locations where meaningful projects could be implemented that would result in improvements to the lakes or surrounding watershed. Storm water drains along roadways in residential areas were also surveyed for treatment feasibility. Surveys included several lake/watershed driving tours, visual inspection and mapping of project sites, and several public and private meetings with landowners and stakeholders. The following projects (refer to Figure 1) are included in this engineering feasibility study based on the surveys' findings:

1. Bank and channel stabilization along Crooked Creek, Big Chapman Lake
2. Bank and channel stabilization along Arrowhead Drain, Little Chapman Lake
3. Manipulations to nine existing storm drain systems

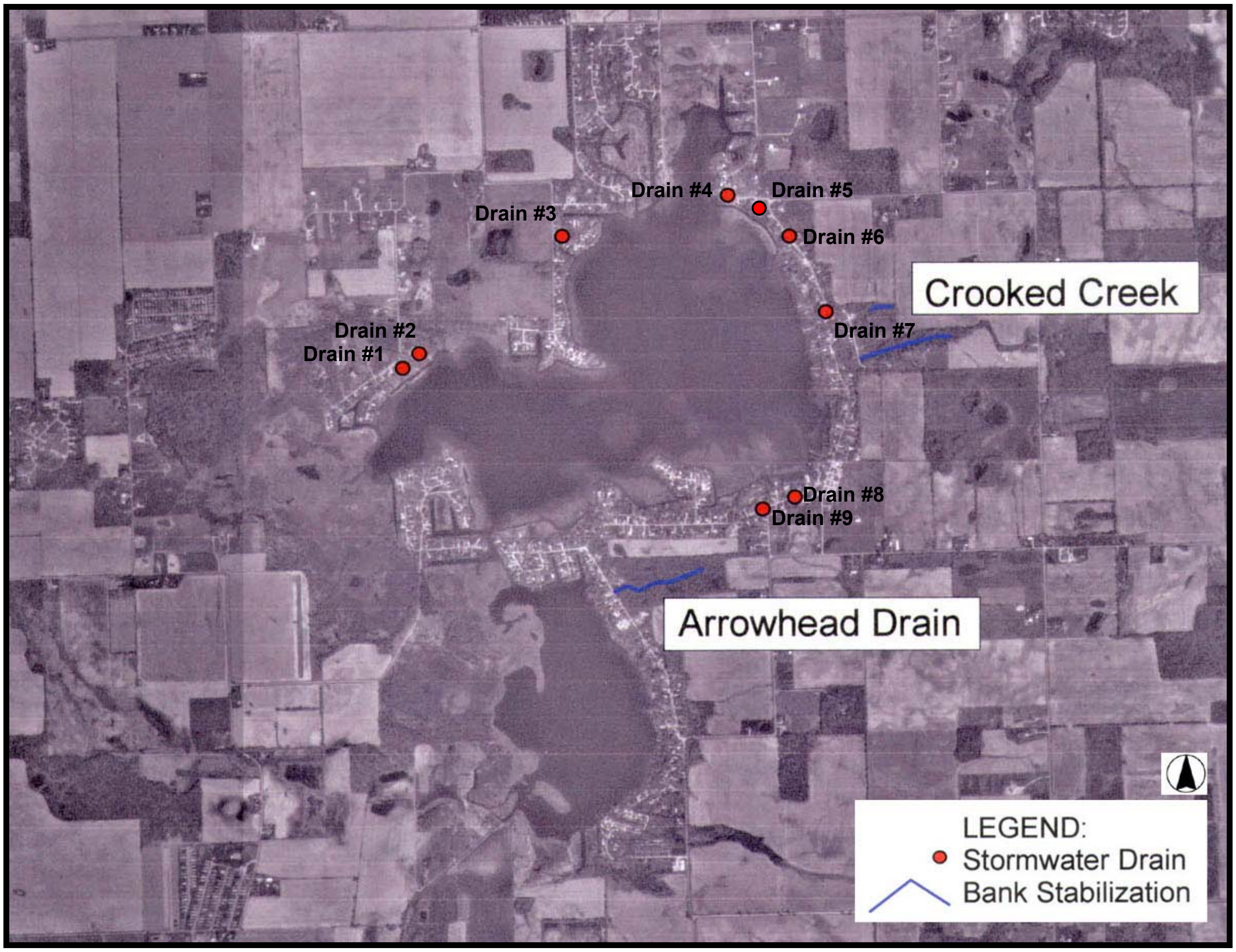

FIGURE 1. Engineering Feasibility Study proposed project locations.

1.3 GOALS AND OBJECTIVES

The goal of this study was to identify feasible projects that could be designed and implemented within a reasonable time frame. A project was deemed feasible if it was physically capable of being constructed, was acceptable to effected landowners, was economically justifiable, and could receive regulatory approval. The feasibility study attempted to ensure project success by investigating all avenues that could potentially cause project failure.

2.0 DESCRIPTION OF STUDY AREA

2.1 LOCATION

The Chapman Lakes Watershed (14-digit hydrologic unit code 05120106020030) encompasses 4,564 acres (1,849 ha) in central Kosciusko County, Indiana (Figure 2). The relatively small Chapman Lakes Watershed is part of the Tippecanoe River Basin, which conducts water to the Wabash River, a tributary of the Ohio River. Four main drainages transport runoff water from the watershed to the Chapman Lakes (Figure 3). The main inlet to Big Chapman Lake is Crooked Creek, which drains approximately 775 acres (314 ha). Little Chapman Lake has three primary drainages: Lozier's Creek, the Arrowhead Park Drain, and the Highlands Park Drain. Lozier's Creek is the largest of the three, draining about 839 acres (340 ha). The Arrowhead Park and Highlands Park Drains carry runoff from approximately 303 and 122 acres (123 and 49 ha) respectively. About 2,417 acres (1,023 ha) of land drain directly to the lakes or through minor drainages before entering the lakes. Water drains from Little Chapman Lake through Heeter Ditch on the Southeast shore and into Deeds Creek. Deeds Creek in turn flows into Pike Lake before entering the Tippecanoe River.

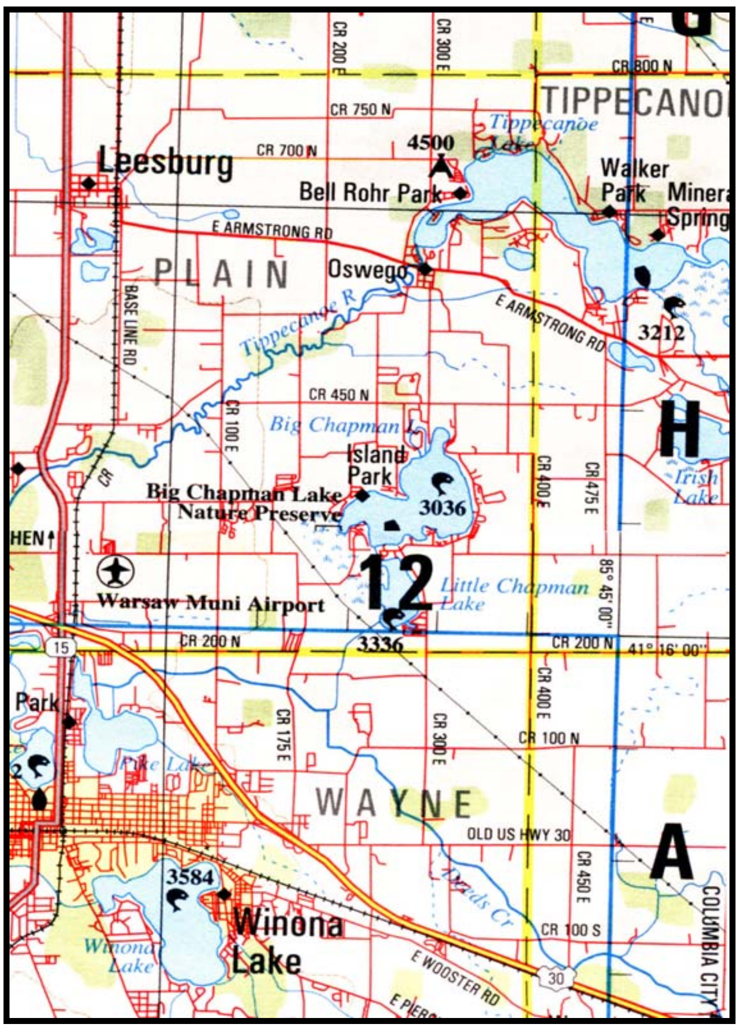

FIGURE 2. General location.

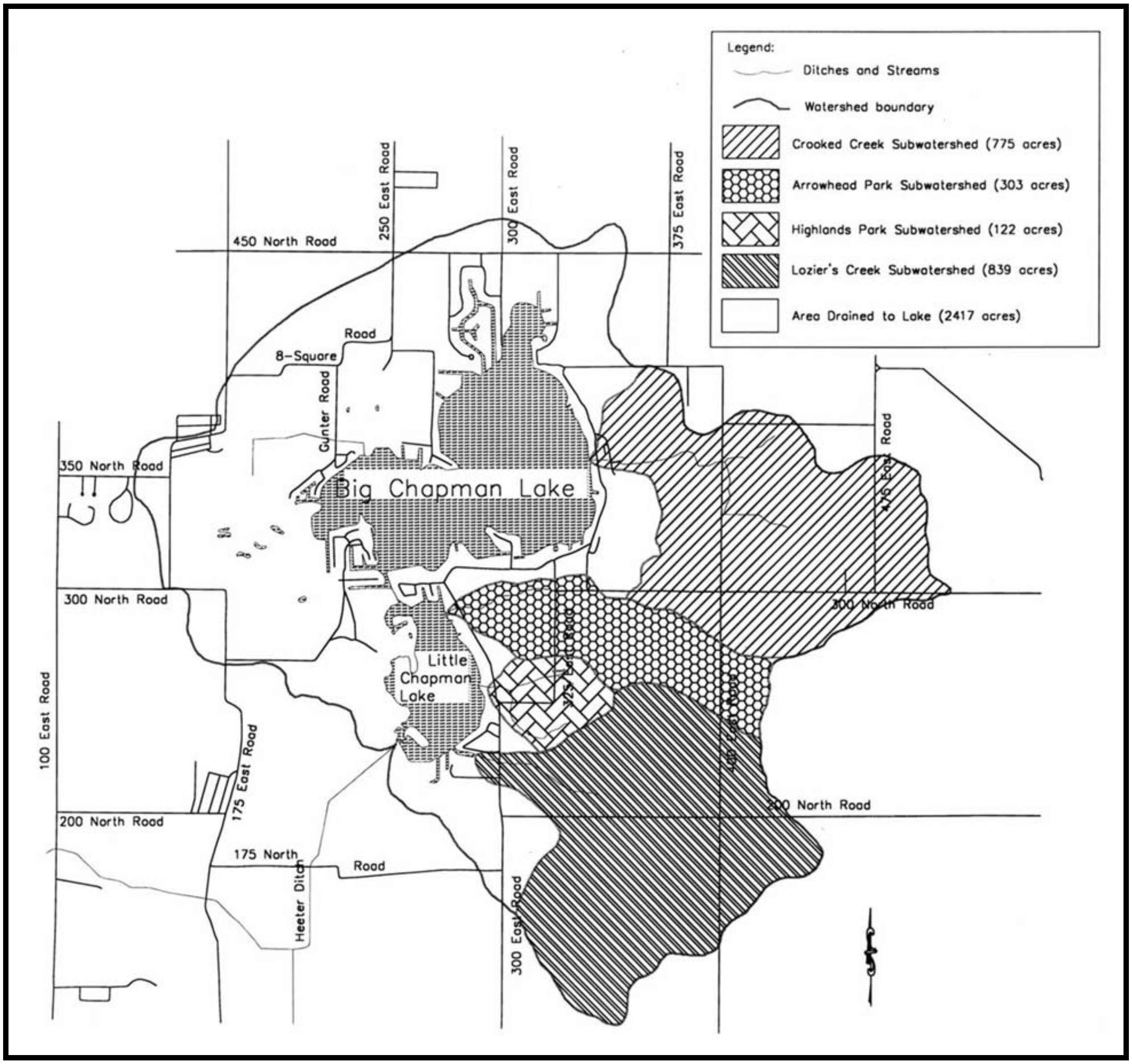

FIGURE 3. Chapman Lake subwatersheds.

2.2 GEOLOGIC HISTORY AND TOPOGRAPHY

The Chapman Lakes and their watershed formed during the most recent glacial retreat of the Pleistocene era. The advance and retreat of the Saginaw Lobe of a later Wisconsin age glacier as well as the deposits left by the lobe shaped much of the landscape found in northeastern Indiana (Homoya et al., 1985). The Saginaw Lobe retreat left a broad, flat to rolling glaciated plain, which has been classified as the Northern Indiana Till Plain Ecoregion (Omernik and Gallant, 1988). Glacial fill and outwash, sandy gravelly beach ridges, flat belts of morainal hills, and bog kettle depressions characterize this ecoregion (Simon, 1997). The topography of the Chapman Lakes Watershed is typical of much of Kosciusko County and was determined to a large extent by glaciation. Land to the east of the lakes exhibits a gently rolling topography. Relief ranges from approximately 940 feet above MSL at the highest point in the watershed to approximately 828 feet at the lakes. Land to the west of the lakes is flatter than the land to the east of the lakes with large wetland expanses lying adjacent to the lakes. Erosion from the more strongly sloped lands to the east was identified as a concern during the 2001 diagnostic study.

2.3 LAND USE

The Chapman Lakes Watershed lies within the Northern Lake Natural Area (Homoya et al., 1985). Natural communities found in this region prior to European settlement included bogs, fens, marshes, prairies, sedge meadows, swamps, seep springs, lakes, and deciduous forests. Like much of the landscape in Kosciusko County, a large portion of the Chapman Lakes Watershed was converted to agricultural land uses. Today, about 69% of the watershed is utilized for agricultural purposes including row crop and pasture (Table 1; Figure 4). Corn, soybeans, and tomatoes are the major crops grown on this land. An additional land use change has been residential development of much of the lakes' northern, eastern, and southern shorelines, which currently composes about 3% of the total watershed acreage. Wetlands and open water account for approximately 23% of the total watershed.

TABLE 1. Land use in the Chapman Lakes Watershed.

Land Use	Acreage	Percentage
Open Water	603.5	13.5%
Low Intensity Residential	114.9	2.6%
High Intensity Residential	9.2	0.2%
High Intensity Commercial/Industrial/Transport	25.9	0.6%
Deciduous Forest	249.2	5.6%
Evergreen Forest	7.0	0.2%
Mixed Forest	0.4	<0.1%
Pasture/Hay	544.1	12.1%
Row Crops	2,575.4	57.5%
Woody Wetland	201.3	4.5%
Emergent Wetland	147.4	3.3%
TOTAL	**4,478.3**	**100%**

Source: USGS/EROS Indiana Land Cover Data Set, Version 98-12.

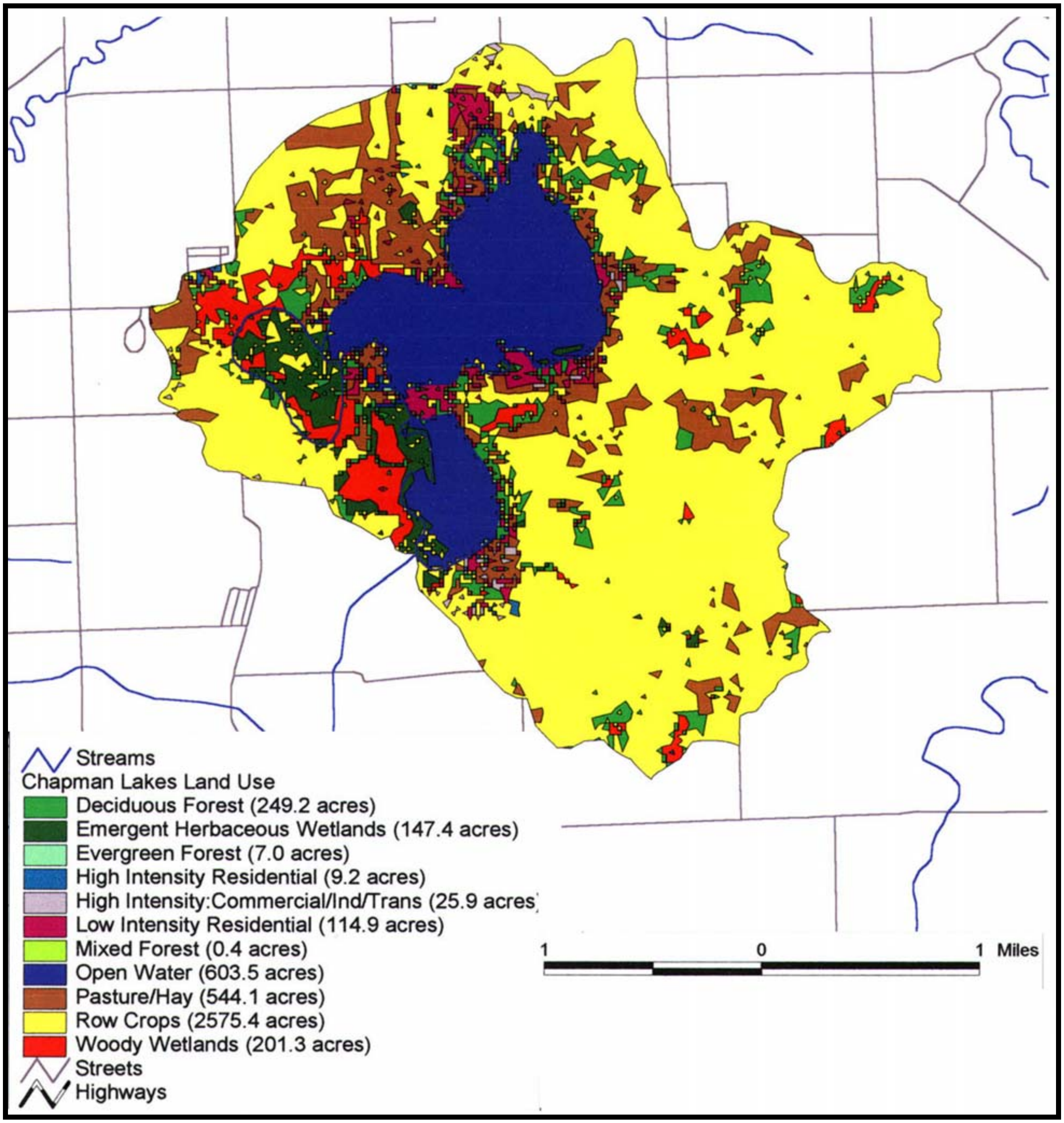

FIGURE 4. Land use.

2.4 SOILS

The soil types found in the Chapman Lakes Watershed are a product of the original parent materials deposited by the glaciers that traversed the area 12,000 to 15,000 years ago. Soils that directly border the lake are of the Houghton-Palms Association, which is primarily composed of mucky, poorly drained soils that formed in organic material. The Crosier-Barry and the Riddles-Wawasee Associations form most of the Crooked Creek and Arrowhead Drain Subwatersheds. Soils of the two associations are loamy, well-drained soils formed in outwash deposits or glacial till (Staley, 1989). The watershed contains a relatively small amount of highly erodible land

(137 acres or about 3% of the watershed). However, 1,334 acres are classified as potentially highly erodible. By subwatershed, Crooked Creek has the greatest percentage of land (50%) mapped in potentially highly erodible units. About 23% or 1,064 acres of the watershed is mapped as hydric soils (JFNew, 2001). Hydric soils developed under wet conditions and are indicative of the historical presence of wetlands. It is likely that projects undertaken within the Chapman Lake Watershed will take place within this variety of soil types and conditions.

2.5 EXISTING AND PLANNED BMPS

Existing best management practices within the Chapman Lakes Watershed include a 73-acre parcel of land enrolled in the Conservation Reserve Program (CRP) just south of Crooked Creek. If not re-enrolled, the parcel will be released from the program this year. Another property owner has established a grassed waterway at the headwaters of Arrowhead Drain. Several lakeshore property owners purchased 35 acres of agricultural land north of Crooked Creek with the intention of developing it as wildlife habitat. Conservation tillage practices are also evident on fields in the watershed. The current study represents the first Best Management Practice (BMP) implementation plan sponsored by the CLCA. The CLCA and the Chapman Lakes Foundation (CLF) plan to pursue funding for all projects listed in the Recommendations Section of the Chapman Lakes Diagnostic Study.

2.6 PRIOR STUDIES

Table 2 documents prior studies conducted at the Chapman Lakes. Most studies conducted in the area have been focused on documenting existing water quality or fishery conditions within the lake. The 2001 diagnostic study was the first study to address watershed management of the areas draining into the Chapman Lakes. The goals of the 2001 Chapman Lake Diagnostic Study were to: 1) identify the sources of pollution within the lakes and the watershed that contribute to eutrophication and sedimentation; 2) evaluate the opinions of lake residents with respect to watershed, shoreline, and lake management; 3) recommend actions that can be taken to protect and restore the ecological integrity and recreational value of the lakes.

TABLE 2. Prior studies conducted in the Chapman Lakes Watershed.

Year	Entity	Topic	Study
1964	IDNR, DFW	Fisheries	Lake Survey Report, Big Chapman Lake
1969	IDNR, DFW	Fisheries	Lake Survey Report, Little Chapman Lake
1986	IDEM	Water Quality	IN Lake Classification System and Management Plan
1976	IDNR, DFW	Fisheries	Big Chapman Lake Fisheries Management Report
1977	IDNR, DFW	Fisheries	Little Chapman Lake Fisheries Management Report
1980	IDNR, DFW	Fisheries	Preliminary Investigations of the Chapman Lake Walleye Population
1981	IDNR, DFW	Fisheries	Fishing Pressure and Harvest at Big Chapman Lake
1989	IDNR, DFW	Fisheries	Largemouth Bass Population Size and Exploitation Rate at Two Natural Lakes
1989	IDEM, CLP	Water Quality	Indiana Clean Lakes Assessment
1991	IDNR, DFW	Fisheries	Big Chapman Lake Fish Population Survey
1994	IDEM, CLP	Water Quality	Indiana Clean Lakes Assessment
1998	IDEM, CLP	Water Quality	Indiana Clean Lakes Assessment
1999	IDNR, DFW	Fisheries	Big Chapman Lake Fish Management Report
1999	IDNR, DFW	Fisheries	Little Chapman Lake Fish Management Report
1999	IDNR, DFW	Mussels	Natural Lakes Mussel Survey
2000	IDEM, CLP	Water Quality	Indiana Clean Lakes Assessment
2001	IDNR, DSC/ JFNew	Watershed Management	Chapman Lake Diagnostic Study
2002	IDNR, DSC/ JFNew	Watershed Management	Chapman Lake Engineering Feasibility Study

IDNR=Indiana Department of Natural Resources
DFW=Division of Fish and Wildlife
IDEM=Indiana Department of Environmental Management
CLP=Clean Lakes Program
DSC=Division of Soil Conservation
JFNew=J.F. New & Associates, Inc.

The following recommendations were part of the 2001 Chapman Lake Diagnostic Study: 1) implement bank and channel erosion control techniques along the lower portions of Crooked Creek; 2) work with local agencies and landowners to install BMPs and restore wetlands in the Crooked Creek Subwatershed; 3) work with Crooked Creek Development, L.L.C. to ensure conservation design; 4) work with local agencies and landowners to install BMPs and restore wetlands in the Lozier's Creek Subwatershed; 5) implement bank and channel erosion control techniques along Arrowhead Drain; 6) consider installing a sanitary sewer system; 7) develop a recreational use management plan; 8) develop a zoning master plan; 9) fit storm water drain pipes with catch basins and filtration technology; 10) develop an aquatic plant management plan.

3.0 PROJECT REVIEW

3.1 BANK AND CHANNEL STABILIZATION AT CROOKED CREEK, BIG CHAPMAN LAKE

3.1.1 Site Description and Alternatives

The Crooked Creek project area is located on the east side of Big Chapman Lake off of Chapman Lake Drive between County Roads 300 and 400N (Figure 1). The Crooked Creek Subbasin occupies an area of 775 acres (314 ha or 1.2 square miles) from its headwaters to its mouth. The drainage area from the downstream end of the project area is less than one square mile. The project area includes 2,000 lineal feet along the mainstem of Crooked Creek and approximately 300 lineal feet of a small adjoining ephemeral tributary. Both are located entirely within property owned by Crooked Creek Development, L.L.C. (Figure 5).

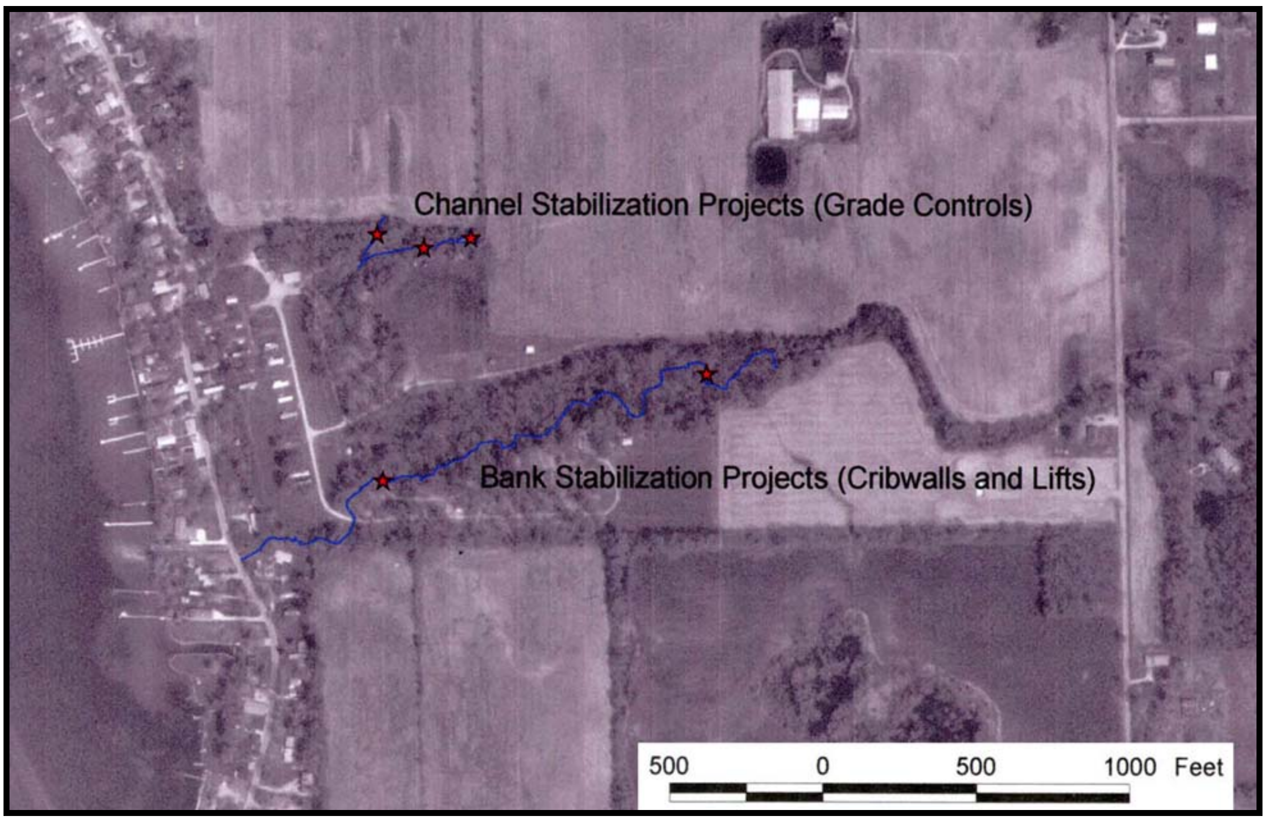

FIGURE 5. Crooked Creek project site.

Crooked Creek remains hydrologically connected to its floodplain. However, bank erosion is occurring in several places along the mainstem (See photos in Appendix A.). Additionally, large pieces of debris (i.e., old culvert pipes, etc.) in the stream have deflected the water's force toward the banks causing sheering in several places. Headcutting and channel erosion are evident within the ephemeral tributary to the north of the mainstem. The creek does not appear to have been dredged or straightened in the past. Soils nearest the creek are loamy sands bordered by sandy loams with interspersed areas of silt loams and gravel. Although the streambanks are not uniformly steep throughout the entire reach, in places of heavy erosion, they average 3-4 feet in height. The watershed of the creek has a relatively high gradient, falling from nearly 890 feet above MSL to 830 feet at its confluence with Big Chapman Lake.

The immediate watershed is currently forested and forested wetland. However, the property is being developed for residential land use. Development plans call for preservation and enhancement of the riparian area for aesthetics and recreation (walking, nature-watching, etc.). The upper watershed is a mixture of agriculture, pastureland, and deciduous forest. As already noted, the watershed is relatively steeply sloped, particularly in its upper reaches. The Chapman Lake Diagnostic Study recommended addressing the headwaters area via work with the Soil and Water Conservation District, the surveyor, and landowners to implement BMPs. A sediment/retention basin has already been built to intercept Crooked Creek before it enters Big Chapman Lake. The basin will work concurrently with the recommendations made in Section 3.1.3 to reduce sediment loading. Maintenance of the basin may be needed as sediment collects over the years.

Alternatives for bank stabilization and restoration in the surveyed reaches included: rip-rap, other forms of hard armor like sheet piling, and bioengineering techniques to establish natural plant materials. Due to desired aesthetic appearance and natural habitat protection, bioengineering techniques employing the use of native plant materials were selected for the Crooked Creek bank stabilization projects. Alternatives for grade stabilization of the tributary included: rock lining the entire tributary or establishing grade controls at selected nick points in the stream. Glacial stone grade control structures were chosen to maintain natural aesthetics, to offer habitat for aquatic organisms, and to eliminate headcutting within the channel at the lowest cost.

3.1.2 Easement and Land Availability Determination

Prior to accessing the Crooked Creek property for surveying purposes, landowner permission was attained from Crooked Creek Development, L.L.C. and from other property owners in the adjacent area. Three of the five property owners granted permission for property access (Appendix B). The other two owners did not respond, but since their properties are adjacent to and not located within the proposed project area, access to their properties was not necessary nor pursued further. The identified bank and channel stabilization project area is on two properties owned by Crooked Creek Development, L.L.C. and the Konkle family. Their permission to access the creek was granted at the inception of this study (Appendix B). Other than erosion control plan implementation and bridge crossings, there are no plans in place for the floodplain area of Crooked Creek. Therefore, the land is available for design and construction of the proposed projects.

3.1.3. Preliminary Design and Conceptual Drawings

Bank stabilization along the mainstem of Crooked Creek is proposed as a series of cribwalls or logs pinned to the banks along approximately 900 lineal feet of stream and soil-encapsulated lift structures along 745 lineal feet. Cribwalls are constructed of logs placed parallel to the streambank, filled with stone, and planted with willow, dogwood, and other shade-tolerant native vegetation (Figure 6). Longitudinal stone toe structures can be placed upstream and downstream of the cribwall. Figure 7 conceptually illustrates the cribwall structure. Soil-encapsulated lift structures are constructed by installing a toe of large diameter fieldstone and wrapping coir fabric around a soil lift that is keyed into the bank (Figure 8). Grasses and woody vegetation are then used to stabilize the lift. Bare-root shrubs will be incorporated into at least the first layer of the lift to establish long-term scour protection, hide the lift fabric, and provide lateral stability. The fabric typically lasts for up to 10 years, allowing enough time to establish permanent vegetative cover for erosion control.

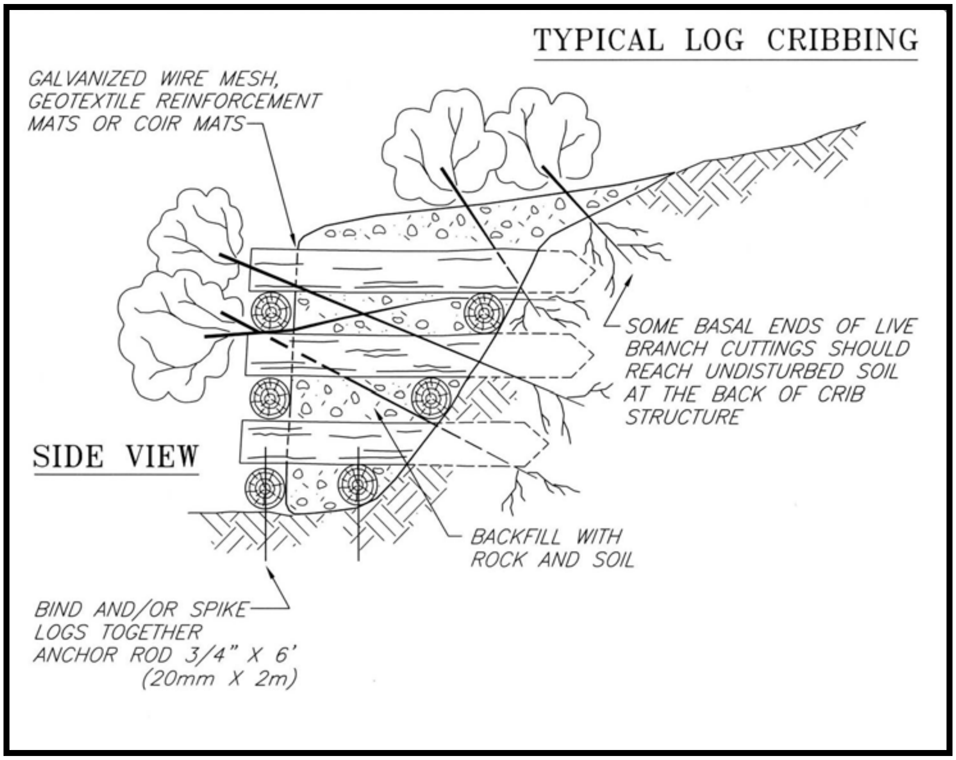

FIGURE 6. Cribwall conceptual diagram.

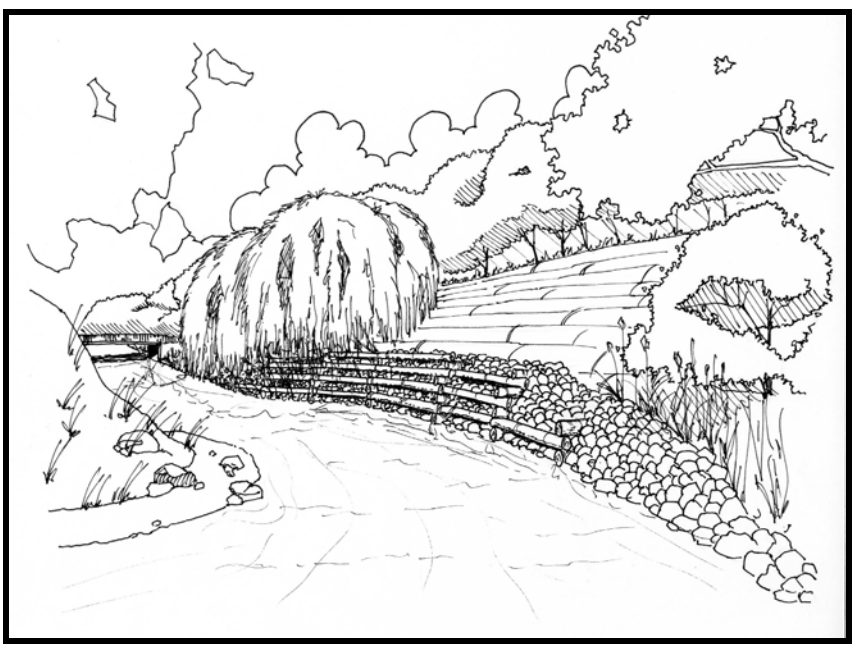

FIGURE 7. Cribwall conceptual rendering.

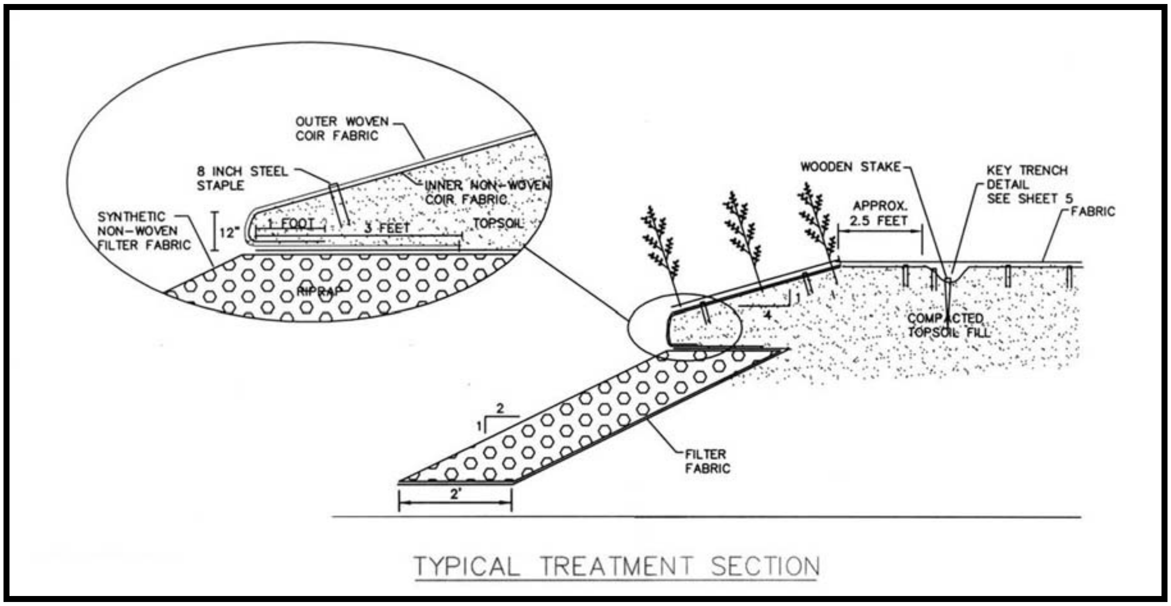

FIGURE 8. Soil encapsulated lift conceptual diagram.

Channel stabilization of the unnamed tributary to the north of the mainstem will consist of three grade control structures constructed using glacial stone (Figure 9). This technique is used to raise the bed of the channel to a level where the two-year flow fills the channel banks. Flows larger than the two-year event would overtop the banks and expend their energy within the floodplain instead of within the channel itself. Fine sediment and sediment-attached nutrients are deposited within the floodplain as well. In this particular situation, grade control structures will prevent the channel from headcutting farther upstream into adjacent agricultural fields. Figure 10 conceptually illustrates a grade control series.

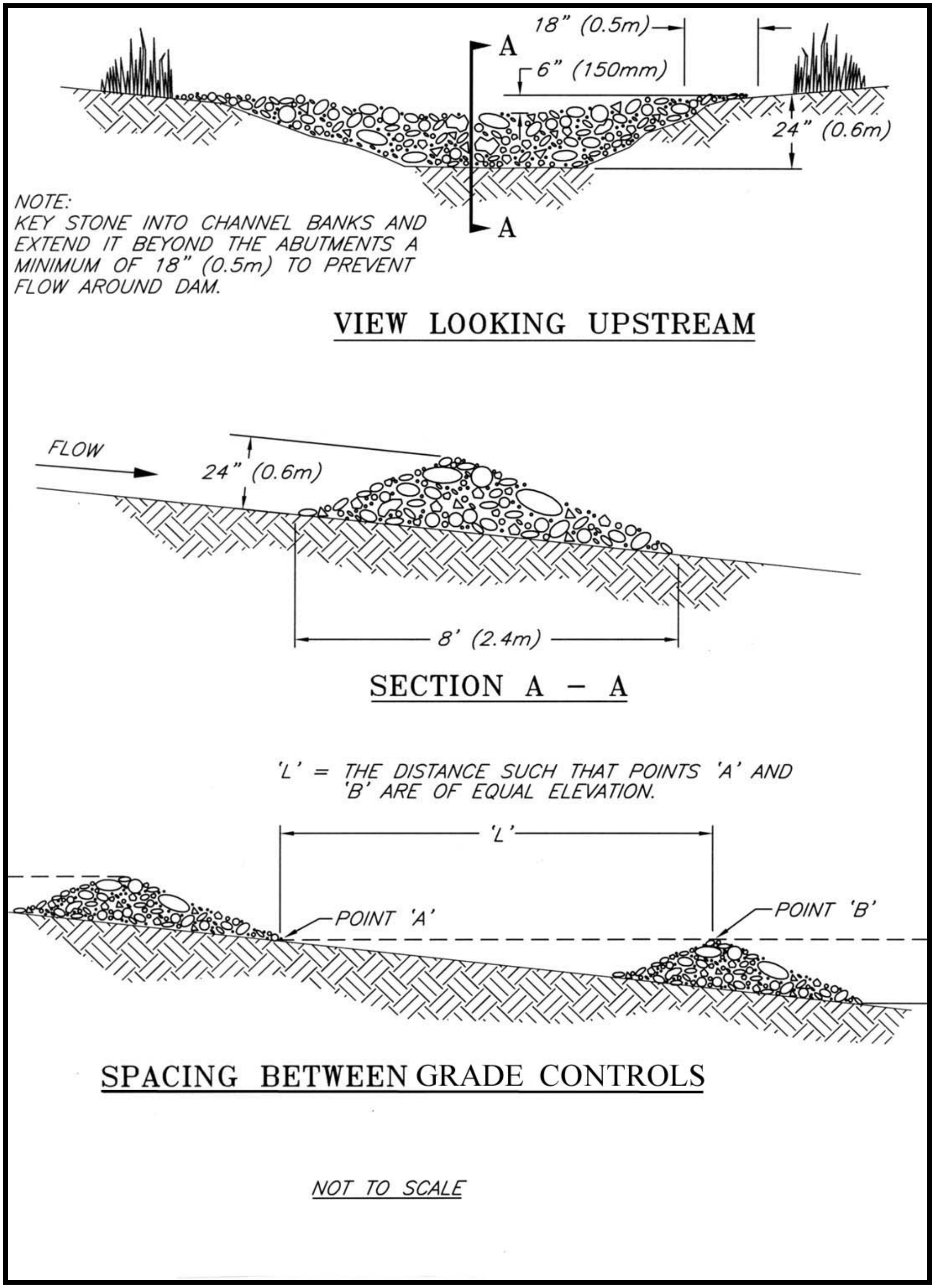

FIGURE 9. Grade control conceptual diagram.

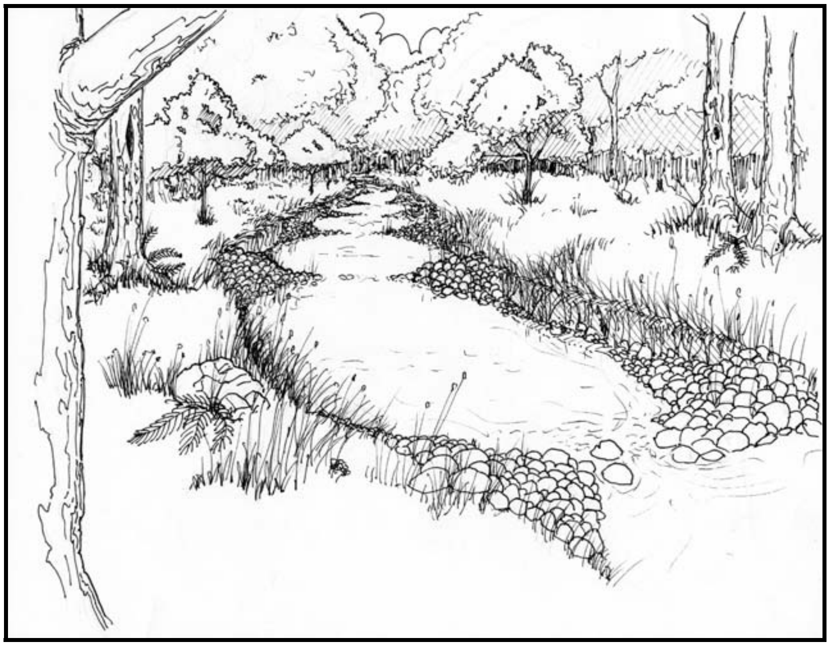

FIGURE 10. Grade control conceptual rendering.

3.1.4. Permit Requirements

Projects associated with Crooked Creek will not require a permit from the Kosciusko County Drainage Board, as it is not a legal drain. An Indiana Department of Natural Resources construction within a floodway permit is not necessary for this project since the drainage area upstream of the project location is less than one square mile. A Section 401 Water Quality Certification from IDEM and a Section 404 Permit from the US Army Corps of Engineers (USACOE) are both required because the creek is considered a "waters of the United States". Preliminary comments were solicited from the Kosciusko County Surveyor's Office, IDEM, and USACOE and are included in Appendix C.

3.1.5. Landowner Agreements

Crooked Creek Development, L.L.C. has agreed to the preliminary design and offered a monetary donation toward project implementation in the amount of $5,000. A copy of the agreement appears in Appendix B. An optional portion of the project is located on the property of Leslie and Marta Konkle and their permission will be sought in the design-build phase as plans are finalized. Construction access roads will be converted to nature trails once project construction has been completed.

3.1.6. Wetland Functional Assessment

The general locations and extents of four floodplain wetlands were mapped during a field survey on April 26, 2002. Figure 11 shows the approximate locations of these wetland areas. All wetlands within the project area are high quality, seep-fed wetlands meriting protection and preservation. Wetland A is located farthest upstream, abuts against the southern slope of the floodplain, and is primarily seep-fed. During the site visit, the wetland was not hydrologically connected to Crooked Creek; however, this connection probably exists during storm events and as subsurface drainage to the creek. The plant community of Wetland A was composed of skunk cabbage (*Symplocarpus foetidus*), swamp white oak (*Quercus bicolor*), sugar maple (*Acer* *saccharum*), jewelweed (*Impatiens* sp.), and marsh marigold (*Caltha palustris*). Wetland B is an oxbow wetland created by channel migration within the floodplain. It lies against the northern bank of the floodplain within 15-20' of the stream. The wetland was hydrologically connected to Crooked Creek during the field survey via two small drainage swales. Vegetation within Wetland B included: swamp buttercup (*Ranunculus septentrionalis*), American elm (*Ulmus americana*), sugar maple (*Acer saccharum*), green ash (*Fraxinus pennsylvanica*), and muscle wood (*Carpinus caroliniana*). Wetland C is also an old oxbow of Crooked Creek lying north of the creek. The wetland is within 30' of the stream and outlets to the creek via what appears to be an abandoned channel connecting the current channel to the old oxbow. Swamp buttercup (*Ranunculus septentrionalis*) dominated the community of Wetland C. Wetland D lies farthest downstream and also within the northern floodplain. A manmade ditch and a channel remnant connect the wet area to Crooked Creek. Wetland vegetation included skunk cabbage (*Symplocarpus foetidus*), marsh marigold (*Caltha palustris*), and jack-in-the-pulpit (*Arisaema triphyllum*).

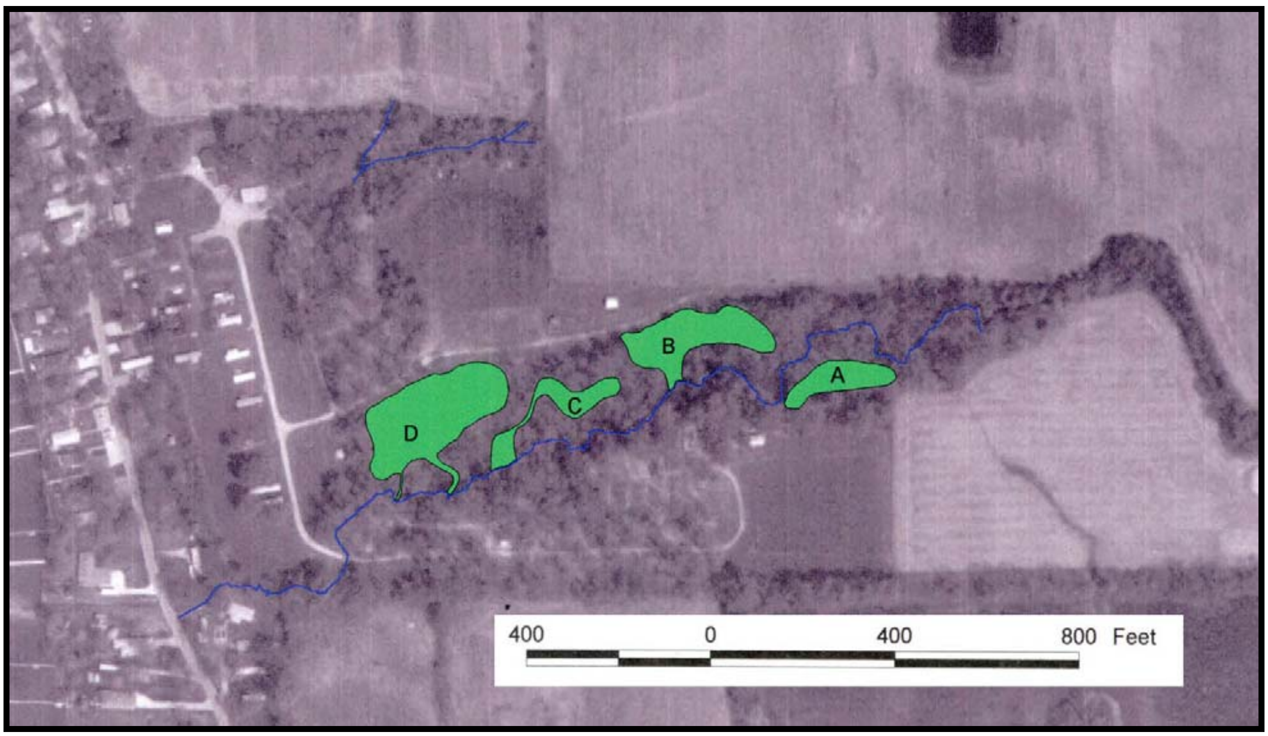

FIGURE 11. Wetlands in the Crooked Creek floodplain.

Wetland functions generally include: runoff filtration, water storage, groundwater recharge and discharge zones, and habitat provision for fauna and flora. The relatively rare, seep-type wooded wetlands within the Crooked Creek floodplain are functionally valuable mechanically, hydrologically, and biologically. Because Crooked Creek remains hydrologically connected to the floodplain, storm runoff that overtops the banks of the creek spreads out into the floodplain. Slowing of runoff in these areas decreases erosive forces downstream, allows for sedimentation of water-born particles, and offers nutrient filtration functions. Although these wetlands probably offer little long-term water storage capacity, they do serve as groundwater discharge zones and provide valuable wildlife habitat in an area where it is estimated that 51% of the original wetland acreage has been destroyed (JFNew, 2001).

Design and construction of the proposed projects will require only minimal disturbance of these high-quality natural areas. As already mentioned, worksite access roads will be designed for later use as a nature trail. The trail will be designed around the wetland areas to ensure minimal impact. In total, the project will require crossing of two 10-foot-wide drainage swales, three 10-foot-wide channel remnants, and one 10-foot-wide manmade channel for a total impact area of about 300 square feet assuming a 10-foot-wide access road. This impact should qualify for the existing regional permit.

3.1.7. Biological and Habitat Integrity Survey

On April 26, 2002, JFNew surveyed the fish community of Crooked Creek by backpack electrofishing for a sample distance of 200 feet and a sample time of 1,026 seconds. Fish collected during the survey were used to calculate an Index of Biotic Integrity (IBI). Karr (1981) first developed the IBI for evaluating biotic integrity of fish communities. Simon and Dufour (1997) further modified and calibrated the IBI for use in the Eastern Corn Belt Plain Ecoregion of Indiana. Biological integrity is defined as, "the ability of an aquatic ecosystem to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to the best natural habitats within a region" (Karr and Dudley, 1981).

The IBI is designed to assess biotic integrity directly through twelve attributes of fish communities in streams. These attributes fall into such categories as species richness and composition, trophic composition, and fish abundance and condition. After data from sampling sites have been collected, values for the twelve metrics are compared with their corresponding expected values (Simon and Dufour, 1997) and a rating of 1, 3, or 5 is assigned to each metric based on whether it deviates strongly from, somewhat from, or closely approximates the expected values. The sum of these ratings gives a total IBI score for the site. The best possible IBI score is 60 (Table 3).

TABLE 3. Attributes of Index of Biotic Integrity classification.

IBI	Integrity Class	Attributes
58-60	Excellent	Comparable to the best situation without human disturbance.
48-52	Good	Species richness somewhat below expectations.
40-44	Fair	Signs of additional deterioration include loss of intolerant forms.
28-34	Poor	Dominated by omnivores, tolerant forms, and habitat generalists.
12-22	Very Poor	Few fish present. Mostly introduced or tolerant forms.
0	No Fish	Repeat sampling finds no fish.

Source: Development of Index of Biotic Integrity Expectations for the Ecoregions of Indiana V. Eastern Corn Belt Plain (Simon and Dufour, 1998).

Table 4 contains data from the biotic assessment of Crooked Creek, and field datasheets are included in Appendix D. The IBI score calculated for the creek places the fish community of Crooked Creek in the "good" integrity class. The only metric to receive a poor score was the percent tolerant individuals metric indicating that the majority of individuals collected in the stream were pollution tolerant. Other metrics received average or good ratings. Due to watershed activities and non-point source pollution, it is unlikely that sensitive species can survive in Crooked Creek. These factors are probably also responsible for the low number of species (four) identified from the stream.

TABLE 4. Data from the biotic assessment of Crooked Creek as sampled on April 26, 2002.

Metric	# or %	Score
# of species	4	3
# of DMS species	1	5
% headwater species	44.3	5
# of minnow species	2	5
# of sensitive species	2	5
% tolerant individuals	55.7	1
% omnivorous individuals	0	5
% insectivorous individuals	44.3	3
% pioneer species	11.5	5
Catch per unit effort	61	3
% simple lithophilic individuals	77	5
% DELT individuals	0	5
IBI Score		**50**
Integrity class		**Good**

DMS = darter, madtom, sculpin
DELT = deformities, erosion, lesions, tumors

Habitat was also evaluated on April 26, 2002 using the Qualitative Habitat Evaluation Index (QHEI) developed by the Ohio EPA for streams and rivers in Ohio (Rankin, 1989 and 1995). Various attributes of the habitat are scored based on the overall importance of each to the maintenance of viable, diverse, and functional aquatic faunas. The type(s) and quality of substrates, amount and quality of in-stream cover, channel morphology, extent and quality of riparian vegetation, pool, run, and riffle development and quality, and gradient are some of the metrics used to determine the QHEI score. Scores typically range from 20 to 100.

The QHEI is used to evaluate the characteristics of a stream segment, as opposed to the characteristics of a single sampling site. As such, individual sites may have poorer physical habitat due to a localized disturbance yet still support aquatic communities closely resembling those sampled at adjacent sites with better habitat, provided water quality conditions are similar. QHEI scores from hundreds of stream segments in Ohio have indicated that values greater than 60 are *generally* conducive to the existence of warmwater faunas. Scores greater than 75 typify habitat conditions that have the ability to support exceptional warmwater faunas (Ohio EPA, 1999).

QHEI metric scores are listed in Table 5 with datasheets in Appendix D. The sampling reach received a QHEI score of 78 indicating the potential of supporting an exceptional warmwater fauna. The pool score was the only metric receiving a poor score (only five of a possible 12 points) due to the relative lack of deep pool habitat.

TABLE 5. QHEI scores for the Crooked Creek assessment reach as sampled on April 26, 2002.

Site	Substrate Score	Cover Score	Channel Score	Riparian Score	Pool Score	Riffle Score	Gradient Score	Total Score
Maximum Possible Score	20	20	20	10	12	8	10	**100**
Crooked Creek	18	12	18	10	5	5	10	**78**

3.1.8. Environmental Impact Assessment

As already discussed, bank and channel stabilization work using bioengineering techniques has been proposed along the mainstem of Crooked Creek and within a small, ephemeral tributary to the creek. Environmental considerations relevant to the proposed project include: wetlands, endangered, threatened, and rare (ETR) species, water quality, flooding, stream habitat, and stream biota.

Lift and cribwall construction along the mainstem of Crooked Creek can proceed with minimal impact to the adjacent wetland areas. Work site access roads will be constructed around the wetland areas. Although an endangered species survey was not conducted, the dominant plant species documented in the Crooked Creek valley did not include any state-listed species. Additionally, the DNR Division of Nature Preserves (DNP) database does not contain documentation of any ETR plant species in the Crooked Creek Subbasin. Since the current project will not require application of fill to the wetlands, it is assumed that these areas will continue to function as they have historically. The proposed bank stabilization projects will also have minimal (if any) impact on flooding. Neither increasing wetland size (which could flood areas higher in the watershed) nor decreasing wetland size (which could flood areas lower in the watershed) during any portion of the project is planned. Bank stabilization should lead to improved water quality in the stream and in Big Chapman Lake as bank erosion is slowed. Sediment and sediment-associated particle loading rates will also be slowed. Over the long-term, bank stabilization will result in more stable habitat within the stream. Rock added for toe stabilization will provide additional in-stream habitat, while vegetation planted on lifts and in cribwalls will provide stream cover. During construction, excavation and localized disturbance of the riparian zone has the potential to impair both water quality and habitat temporarily. To shorten the period of local disturbance, construction of the proposed project would be ideal if it could occur concurrently with the development of Greystone. Biotic integrity in Crooked Creek was rated as “good” during the Spring 2002 fish community assessment. No ETR species were documented during the survey nor does the IDNR DNP database list sightings of any rare or protected fauna in the drainage.

Grade control structures within the small ephemeral tributary to Crooked Creek can also proceed with minimal impact to environmental factors. Since there are no wetlands in the tributary subbasin area, no impacts to wetlands or their fauna or flora are anticipated. As in the area adjacent to Crooked Creek, no ETR sightings have been recorded. Ecological integrity in this ravine is more impaired than in the Crooked Creek floodplain due to the dumping of debris and other refuse in previous years. Garlic mustard (*Alliaria petiolata*) and multiflora rose (*Rosa multiflora*), two species typical of disturbed areas, dominate the understory in the tributary’s riparian zone. Grade control structures along the ephemeral stream are intended to slow water down during storm events and prevent further channel incision. Even with grade control structures in place, the channel is large enough to accommodate storm flows without overtopping its banks and flooding adjacent land. Channel erosion and sediment loading will decrease with a concurrent improvement in water quality as the structures prevent further headcutting of the stream. There are not any likely impacts of the project on fish and macroinvertebrates in this ephemeral drainage.

3.1.9. Unusual Physical and Social Costs

Unusual physical costs associated with design and construction of the project include: avoiding wetland areas, attaining access to the streambanks while keeping the riparian corridor intact and undamaged, loss of a small amount of wetland area where work site access roads will be constructed, and clean up and disposal of refuse that has been discarded in the tributary ravine. Additional construction occurring in the area since spring of 2002, and likely to continue for the next few years, may affect project implementation.

3.1.10. Opinions of Probable Cost and Proposed Time Line

The opinion of probable cost is $96,438 for bank stabilization (lifts and cribwalls) and channel stabilization (grade controls) in the Crooked Creek Subbasin (Table 6).

TABLE 6. Opinion of probable cost for bank and channel stabilization in the Crooked Creek Subbasin.

Item	Cost	Unit	Number	Total
Engineering and permitting	15%	each	1	$11,273
Construction services	10%	each	1	$7,515
Subtotal				**$18,788**
Cribwall structure (1-2 logs)	$25	foot	490	$12,250
Cribwall structure (3-4 logs; includes plants)	$50	foot	405	$20,250
Fabric lifts (includes plants)	$50	foot	745	$37,250
Grade controls	$1,800	each	3	$5,400
Mobilization/demobilization	$2,500	each	1	$2,500
Construction Subtotal				**$77,650**
Total				**$96,438**

The recommended project timeline is based on residential development construction that is currently in progress at the site. The proposed project should be constructed while the entire property is under development to avoid having to disturb the site a second time. Once Crooked Creek Development, L.L.C. begins to sell plots for homebuilding, project construction may be complicated due to the increased number of stakeholders. CLCA applied for design-build LARE funding in early 2002, and it is recommended that the proposed project be designed and constructed as soon as funding becomes available.

3.1.11. Project Justification and Estimation of Impact

Although streambank erosion is a natural process, drainage practices in the Crooked Creek Subbasin have artificially exacerbated the process. Artificial drainage of the Crooked Creek watershed landscape increases the volume and velocity of water delivered to the channel both during storm flow events. During high discharge events, rapid flows carry away bank material increasing the rate of lateral migration and number of high gradient banks. The high gradient banks lead to mechanical bank failure and deposition of more material at the base of the slope where base flow discharges can carry the material downstream (Waters, 1995). As the slumped material is removed, bank slope is again increased and the process repeats itself. Cultural processes like artificial drainage exacerbate the problem by increasing the amplitude of discharge events. In a 1964 study of relationships among sediment, discharge, and land use, Striffler found that "streams in cultivated and pastured watersheds had heavy sediment deposits and variable flows." Streambank erosion was identified as an important contributor to net sediment loading. Additionally, in some cases researchers have attributed >50% of the sediment load carried by small streams in the Midwest to channel erosion (Roseboom and White, 1990; Isenhart et al., 1997).

The storm event sampled during the diagnostic study was a six-month event during which the stream possessed a sediment loading rate of 2,278 kg/d (2.5 tons/d). If 50% of the sediment load is due to bank erosion, then 1,139 kg/d is loaded to the lake from the banks during a six-month storm event. Although the current project will not completely eliminate bank erosion, it is feasible to expect an erosion rate reduction of 75%. This correlates to a reduction of 854 kg/d during a six-month storm event. Assuming two six-month storm events per year, the project will reduce sediment loading to Chapman Lake by 1,708.5 kg (3,766 lbs or 1.9 tons) per year. With a project cost of $96,438, sediment reduction will cost about $25 per lb over a period of one year; however, since the life expectancy of the project is much longer than one year (probably closer to 25 years), the cost of sediment reduction is estimated at about $1 per lb.

Sediment delivery to the lake has important biological, recreational, and aesthetic impacts. Both biologists and lake users view these impacts negatively. Additionally, sediment removal via dredging is costly and can impact the biota. In 2000, 1,100 cubic yards (280 cubic meters) of sand had been deposited at the mouth of Crooked Creek in Big Chapman Lake. Based on this volume of material, it is estimated that dredging may cost as much as $40,000. If sediment loading from the watershed were not controlled, dredging would need to be repeated every 5-10 years (an activity that the IDNR will not permit). In conclusion, a project that will reduce sediment delivery to the lake by the estimated amount is justifiable based on cost-benefit analysis.

3.2 BANK AND CHANNEL STABILIZATION AT ARROWHEAD DRAIN, LITTLE CHAPMAN LAKE

3.2.1. Site Description and Alternatives

The Arrowhead Drain Subwatershed drains 303 acres (122 ha or 0.47 square miles) of largely agricultural and residential land to the northeast corner of Little Chapman Lake (Figure 1). Arrowhead Drain is a legal drain meaning that the Kosciusko County Surveyor's Office can collect ditch assessment fees in order to maintain proper drainage. Arrowhead Drain is legally known as the Shroyer Arm of Heeter Ditch. The reach assessed during this feasibility study included 1,512 lineal feet of the mainstem of Arrowhead Drain located entirely within property owned by Mr. and Mrs. William McDaniel (Figure 12).

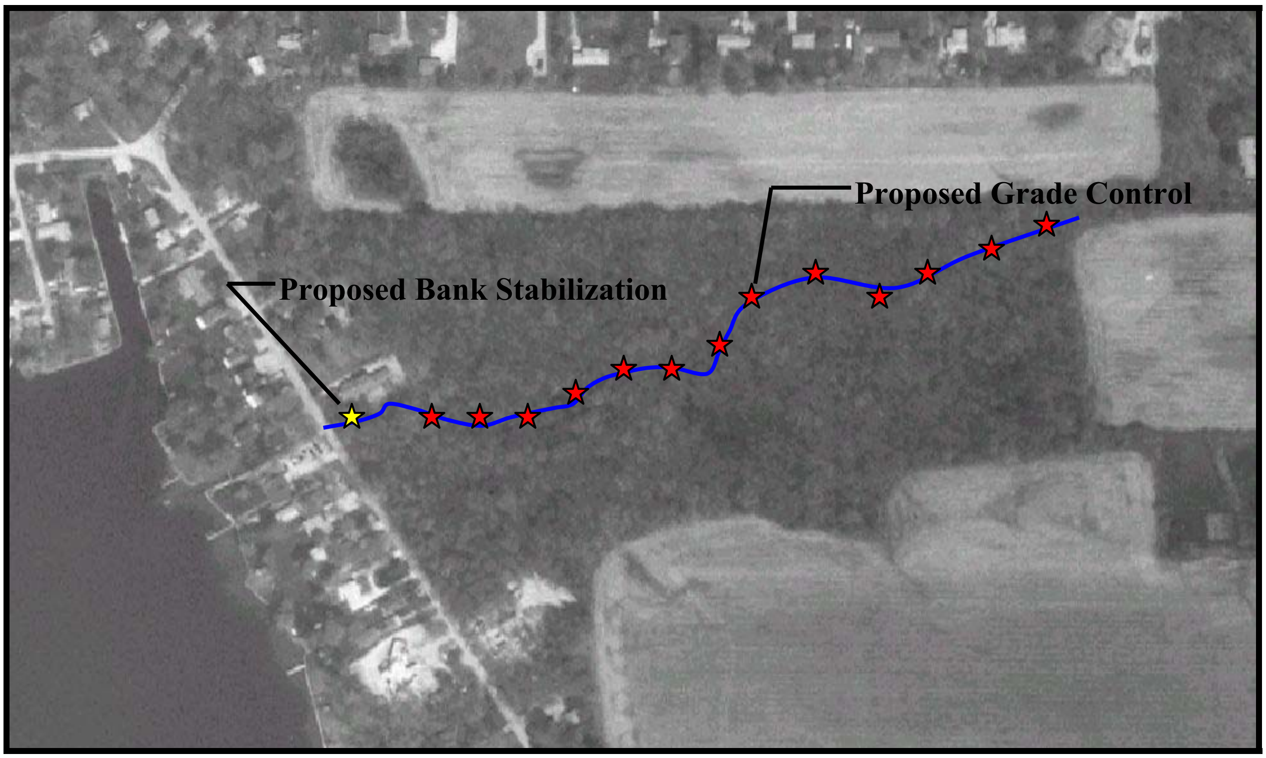

FIGURE 12. Arrowhead Drain project site.

Arrowhead Drain has been dredged in the past to promote drainage, resulting in an incised or degraded channel bed that is hydrologically disconnected from its floodplain. The entrenched channel appears to prevent normal runoff flows from reaching the floodplain. If the stream water could access the stream's floodplain during high flow periods: 1) the amount of fine sediment and nutrients reaching Little Chapman Lake would be reduced; 2) downstream flood peaks and flood risk would be attenuated; 3) flow volumes and velocities during storm events would be reduced and consequently bed, channel, and bank erosion and incision would be lessened. Bank erosion is evident on the north bank near the creek's mouth on the northeast side of Chapman Lake Drive (Figure 12). Recent erosion and bank retreat was evident upon inspection. Adequate bank protection was absent. (See photographs in Appendix A.)

Soils bordering and near the creek are loams and sandy loams. The streambanks are steep throughout the entire project reach, as anthropogenic disturbances (dredging) have resulted in an incised stream channel. The watershed slopes from approximately 900 feet mean sea level at the headwaters to 830 feet mean sea level at the drain's confluence with the lake.

The land surrounding the project area is forested. Forested wetland habitat also exists in the project area. The owner of the property may consider developing the tract in the future (William McDaniel, personal communication). The upper portion of the watershed is a mixture of agricultural land and pastureland.

Alternatives for bank and channel erosion control in the study reach include engineering techniques to reconnect the stream and its floodplain: channel diversion, complete channel remeandering, levee (dredged spoils) removal, and grade control installation at selected nick points in the stream. Because channel diversion and remeandering can be costly and because the techniques require a large area for construction, installation of a series of grade control structures and levee removal were pursued as feasible alternatives. Glacial stone grade control structures have a natural appearance, offer habitat for aquatic organisms, reduce erosion and head-cutting within the channel, and help reconnect the stream with its floodplain during larger storm events.

3.2.2 Easement and Land Availability Determination

One individual currently owns the parcel of land where the grade control project is proposed. Prior to accessing the project area, permission was attained from the property owner (Appendix B). Presently, the property owner has no definite plans for the small drain or its floodplain, so the land is available for design and construction of the proposed project.

3.2.3 Preliminary Design and Conceptual Drawings

Channel stabilization along Arrowhead Drain will consist of 13 (±2) grade control structures spaced within the 1,512-foot reach and removal of remnant dredged spoils from the southern bank. Grade control structures are constructed of glacial stone (Figures 9 and 10); spacing between structures should range between 5-7 bank-full widths. Based on measurements made during site visits, average bank-full width is 20 feet; therefore, structures should be approximately 120 feet apart. Dividing the average channel fall by the number of structures provides an estimate of weir height. Topographical maps indicate that the approximate channel fall is 12 feet in this reach; therefore, each weir should be about one foot high. However, since the goal of this project is not only to stabilize the bed of the channel but also to raise it several feet, the weir height should be raised to somewhere between two and four feet to create an average slope of 0.008% between structures. The upstream gradient of each grade control structure should be 4:1 and the grade control structure should have a backslope of 20:1. Channel banks should be armored with stone at the entrance to and extending downstream along the back slope of the grade control structure.

The objective is to space the grade control structures so that the water pooling upstream (behind) one structure reaches the toe of the next structure upstream. The resulting series of pools provide habitat for fish, amphibians, and aquatic invertebrates. The new flow line created by the series of grade control structures follows the same gradient as the original channel. However, the grade control structure height is set so that during a two-year precipitation event, the stream water will rise out of its banks and into the floodplain. Removing levees created by dredged spoils from the streambank would enhance this. Over time, the pools will be filled with sediment and debris from the stream resulting in a permanently raised streambed.

Bank stabilization is deemed necessary on the north bank of Arrowhead Drain just east of Chapman Lake Drive, due to a steep cut bank at the edge of a maintained lawn. The area needing direct stabilization is approximately 100 feet long. This area should be stabilized with a direct application of aggregate (placing rock on the slope) or a bio-engineered approach to establish permanent vegetated protection. A typical bio-engineered approach is described in the previous section on Crooked Creek (3.1.3).

3.2.4. Permit Requirements

Projects associated with Arrowhead Drain will require a permit from the Kosciusko County Drainage Board since the creek is a legal drain. An Indiana Department of Natural Resources construction within a floodway permit is not necessary for this project since the drainage area upstream of the project location is less than one square mile. A Section 401 Water Quality Certification from IDEM and a Section 404 Permit from the US Army Corps of Engineers (USACOE) are required because Arrowhead Drain is a "waters of the United States" and wetlands exist in the drain's floodplain. Preliminary comments were solicited from the Kosciusko County Surveyor's Office, IDEM, and USACOE and are included in Appendix C.

3.2.5 Landowner Agreements

The McDaniels' have signed a letter supporting the project as conceptually designed (Appendix B).

3.2.6 Wetland Functional Assessment

The ditch was walked in the fall of 2001 and again in the spring of 2002. Wetlands are located in the vicinity of the ditch but will not be affected by the project due to the fact they are more than 50 feet from the top of bank.

3.2.7. Biological and Habitat Integrity Survey

On April 26, 2002, JFNew surveyed the fish community of Arrowhead Drain by backpack electrofishing for a sample distance of 200 feet and a sample time of 1,026 seconds. Using data collected during the survey, JFNew calculated an Index of Biotic Integrity (IBI) for the stream. Karr (1981) first developed the IBI for evaluating biotic integrity of fish communities. Simon and Dufour (1997) further modified and calibrated the IBI for use in the Eastern Corn Belt Plain Ecoregion of Indiana. Biological integrity is defined as, "the ability of an aquatic ecosystem to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to the best natural habitats within a region" (Karr and Dudley, 1981).

The IBI is designed to assess biotic integrity directly through twelve attributes of fish communities in streams. These attributes fall into such categories as species richness and composition, trophic composition, and fish abundance and condition. After data from sampling sites have been collected, values for the twelve metrics are compared with their corresponding expected values (Simon and Dufour, 1997) and a rating of 1, 3, or 5 is assigned to each metric based on whether it deviates strongly from, somewhat from, or closely approximates the expected values. The sum of these ratings gives a total IBI score for the site. The best possible IBI score is 60 (Table 3).

Table 7 contains data from the biotic assessment of Arrowhead Drain, and field datasheets are included in Appendix D. The IBI score calculated for the creek places the fish community of Arrowhead Drain in the "fair" integrity class. The metrics that received poor scores were the percent omnivore individuals, percent insectivore individuals, percent lithophilous individuals, and percent DELT individual metrics. The IBI requires that these metrics score poorly if fewer than fifty individual fish are collected during sampling. Other metrics received average or good ratings. Due to watershed activities and non-point source pollution, it is unlikely that sensitive species can survive in Arrowhead Drain. These factors are probably also responsible for the low number of species (five) identified from the stream.

TABLE 7. Data from the biotic assessment of Arrowhead Drain as sampled on April 26, 2002.

Metric	# or %	Score
# of species	5	3
# of DMS species	2	5
% headwater species	10.3	5
# of minnow species	3	5
# of sensitive species	1	5
% tolerant individuals	2.6	5
% omnivorous individuals	<50 Individuals	1
% insectivorous individuals	<50 Individuals	1
% pioneer species	5.1	5
Catch per unit effort	39	3
% simple lithophilic individuals	<50 Individuals	1
% DELT individuals	<50 Individuals	1
IBI Score		**40**
Integrity class		**Fair**

DMS = darter, madtom, sculpin
DELT = deformities, erosion, lesions, tumors

Habitat was also evaluated on April 26, 2002 using the Qualitative Habitat Evaluation Index (QHEI) developed by the Ohio EPA for streams and rivers in Ohio (Rankin, 1989, 1995). Various attributes of the habitat are scored based on the overall importance of each to the maintenance of viable, diverse, and functional aquatic faunas. The type(s) and quality of substrates; amount and quality of in-stream cover; channel morphology; extent and quality of riparian vegetation; pool, run, and riffle development and quality; and gradient are some of the habitat attributes used to determine the QHEI score. Scores typically range from 20 to 100.

The QHEI is used to evaluate the characteristics of a stream segment, as opposed to the characteristics of a single sampling site. As such, individual sites may have poorer physical habitat due to a localized disturbance yet still support aquatic communities closely resembling those sampled at adjacent sites with better habitat, provided water quality conditions are similar.

QHEI scores from hundreds of stream segments in Ohio have indicated that values greater than 60 are *generally* conducive to the existence of warmwater faunas. Scores greater than 75 typify habitat conditions that have the ability to support exceptional warmwater faunas (Ohio EPA, 1999).

QHEI metric scores are listed in Table 8 with datasheets in Appendix D. The overall QHEI score indicates that habitat may be impairing aquatic life in the creek. Scores for pool development (3 of 12), riffle development (2 of 8), channel morphology (9 of 20), and instream cover (6 of 20) were below those observed in streams with exceptional habitat. This lack of habitat is likely responsible for depressed IBI scores within the Arrowhead drainage.

TABLE 8. QHEI scores for the Arrowhead Drain assessment reach as sampled on April 26, 2002.

Site	Substrate Score	Cover Score	Channel Score	Riparian Score	Pool Score	Riffle Score	Gradient Score	Total Score
Maximum Possible Score	20	20	20	10	12	8	10	**100**
Arrowhead Drain	13	6	9	9	3	2	8	**50**

3.2.8. Environmental Impact Assessment

Environmental considerations relevant to the proposed project include: wetlands, endangered, threatened, and rare (ETR) species, water quality, flooding, stream habitat, and stream biota. Grade control structures within the Arrowhead Drain Subwatershed can proceed with minimal impact to environmental factors. Although an endangered species survey was not conducted, the dominant plant species documented in the Arrowhead Drain project area did not include any state-listed species. Additionally, the DNR Division of Nature Preserves (DNP) database does not contain documentation of any ETR plant species in the Arrowhead Drain Subbasin. Since the proposed project will not impact the wetlands near the drain, it is assumed that these areas will continue to function as they have historically. If correctly sized, grade control structures will force water in Arrowhead Drain to flow out of the channel and into the floodplain during large storm events. Steep upland slopes will limit the area flooded during these storm events. No permanent housing structures are located within this area; therefore, no damage will result from floodwaters. Species in the riparian area are already subjected to intermittent flooding; increasing the frequency of flooding should not negatively impact the existing vegetation. Channel erosion and sediment loading rates from the site will decrease with a concurrent improvement in water quality. The grade control structures will also prevent further head cutting of the stream and the water quality degradation that results from this head cutting. Glacial stone used to build the structures will offer in-stream habitat. Biotic integrity was rated as fair during the spring of 2002 assessment of the fish community. This assessment suggests that the site has been previously impacted by anthropogenic factors. Fish communities of the type observed in Arrowhead Drain are dominated by tolerant species adapted to human induced environmental stresses. The lack of sensitive or ETR species suggests that the fish community has already adjusted to existing environmental stresses and poor water quality. The fish community will likely be minimally impacted by project construction. Any impacts would be temporary.

3.2.9. Unusual Physical and Social Costs

Unusual physical costs associated with design and construction of the project include: avoiding wetland areas, attaining access to the streambanks while keeping the forested riparian corridor intact, and disposal of refuse that has been previously discarded in the tributary ravine. Access through the forested area to the grade control locations is the most difficult physical hurdle to overcome.

3.2.10. Opinions of Probable Cost and Proposed Time Line

The opinion of probable cost is $67,725 for channel and bank stabilization (grade controls) in the Arrowhead Drain (Table 9). Costs are greater for individual grade controls and engineering due to the fact that access and surveying is difficult in the wooded corridor.

TABLE 9. Opinion of probable cost for bank and channel stabilization in Arrowhead Drain.

Item	Cost	Unit	Number	Total
Engineering and permitting	20%	Each	1	$9,675
Construction services	20%	Each	1	$9,675
Subtotal				**$19,350**
Bank Stabilization at Chapman Lake Road	$50	Foot	100	$5,000
Grade controls	$2,400	Each	13	$31,200
Mobilization/demobilization	$2,500	Each	1	$2,500
Construction Contingency	25%	Each	1	$9,675
Construction Subtotal				**$48,375**
Total				**$67,725**

The recommended project timeline is based on LARE grant funding cycles. It is recommended that CLCA apply for design-build LARE funding in early 2003, contract out design-build services in late 2003 after grant award, design the project in the winter of 2003-2004 and build the project in 2004.

3.2.11. Project Justification and Estimation of Impact

Although erosion is a natural process, farming practices in the Arrowhead Drainage have artificially exacerbated the erosion process. Artificial drainage associated with farming practices increases the volume and velocity of water delivered to the channel during storm flow events. Many streams, such as Arrowhead Drain, were dredged deeper to accommodate the increased discharge after storms. The energy from these confined flows is then directed at the bottom of the stream, incising the streambed. This further concentrates the flow and energy. Eventually, the stream begins to erode laterally to create a new floodplain that is of adequate size to handle the discharge.

In 2000, the diagnostic study documented an area of sediment deposit measuring 1.4 acres (0.6 ha) and averaging three feet (0.9 m) deep at the mouth of Arrowhead Drain in Little Chapman Lake. This nutrient enriched sediment supported a dense growth of Eurasian water milfoil. Based on this amount of material, it is estimated that dredging may cost as much as $25,000 at this location. The storm event sampled during the diagnostic study was a six-month event during which the stream loaded sediment at a rate of 134 kg/d (0.15 tons/d). Although the current project will not eliminate total suspended sediment loads, it is feasible to expect that total suspended sediment loads will be reduced by 50%, meaning that with project implementation sediment loading could be reduced by an estimated 67 kg/d (0.075 tons/d) during all storms greater than a six-month event. While this figure is substantially lower than that estimated for the Crooked Creek project, much of the sediment in the lake was probably deposited there during period of active construction in (dredging) and around the drain and prior to the grassed waterway installation in the headwaters. The project becomes necessary when considering that the goal is ultimately to remove the accumulated nutrient rich sediments from Little Chapman Lake, and all feasible actions to reduce sediment release from the watershed must be attempted prior to securing in-lake dredging permits. Additionally, if sediment loading from the watershed is not controlled, dredging may need to be repeated every 10-20 years.

3.3 STORM DRAINS, BIG CHAPMAN LAKE

3.3.1 Drain Description and Alternatives

JFNew identified nine storm drains leading to Chapman Lakes from the public roads during the duration of this study (Figure 1). More drains probably exist and any pollution reduction techniques prescribed for these nine drains can be applied to any other drains that were not found during the course of this study. Pollution from these drains was not directly measured but varies at each drain. For example, at least one drain may be emitting raw sewage; others likely release sediment, road salts, and hydrocarbons. All of the drains examined could be improved in some way to reduce their respective pollutant loads to the lake. The following paragraphs present alternative and recommended actions for each of the nine drains.

Located at the northwest side of Chapman Lake on the loop off Gunter Road (EMS 27A and 27B), Drain 1 lies at the southern end of Gunter Road at the bottom of the hill. The inlet has a 16-inch round grated covering (Figure 13). The drain's inlet is about 60 feet from the lake. A 6-inch plastic pipe routs water from the inlet to the east under the road and presumably into Drain 2. The inlet for Drain 2 is located on the northeast corner of the Gunter Road loop. It also has a 16-inch round grated covering (Figure 14). Drain 2 accepts water from the south and east (Drain 1) and from an 8-inch pipe coming from the west. From Drain 2's inlet, the water drains via a 6-inch pipe east-northeast across approximately 150 feet of private open ground before discharging into a wetland and creek (Figure 15).

FIGURE 13. Grated inlet for Drain 1.

FIGURE 14. Grated inlet for Drain 2.

FIGURE 15. Discharge path for Drain 2.

Drains 1 and 2 deliver an unknown load of sediments, salt, hydrocarbons, and other pollutants from the roadway and adjacent residential property to Chapman Lake without any treatment. Paint was observed on the inlet grate to Drain 2 during a site inspection. The options for treating the stormwater in this neighborhood include: 1) installing swirl collectors; 2) eliminating the drains and regrading the road to allow water to drain to shallow treatment swales or infiltration trenches; 3) constructing a treatment swale at the same elevation as the existing drain pipes; 4) replacing current drain piping with perforated infiltration pipes; 5) scheduling maintenance of the existing catch basins on the drain inlets; 6) educating area residents regarding the drainage system and effects of discharging pollutants to these drains.

Kosciusko County officials expressed a preference for implementing alternatives 5 and 6 (Robert Ladson, personal communication). County officials stated that they would support treatment swales; however, at this location, treatment swales would have to be completed in conjunction with rebuilding of the road. Therefore, it is suggested that residents be educated via personal communication or written notice and that the county schedule regular maintenance of the existing catch basins until the time that the road is reconstructed.

Drain 3 is located on northwest side of Big Chapman Lake off County Road 250 East. The drain has an inlet on the north side of EMS 28C Lane and empties to a lake channel through a 10-inch plastic pipe (Figure 16). The pipe passes between two private residences, just to the east of the house on the corner of County Road 250 East and EMS 28C Lane. The discharge of raw sewage from this pipe into the lake was observed during several site visits. A septic system treating wastewater from one of the adjacent residences may be directly tiled into Drain 3. There are two potential solutions to treat the problem noted at this site: 1) persistence in reporting violations to the Health Department; 2) offering the residents money to rebuild the section of pipe and repair the leach field.

The County Health Department was called on several occasions to address this issue. They have so far failed to publicly respond. JFNew recommends contacting the owner and establishing a fund to repair the system.

FIGURE 16. Outlet pipe for Drain 3 at Chapman Lake.

The main inlet to Drain 4 is located by Nellies Bay on the northeast corner of Chapman Lake Drive at its junction with County Road 400 North (Figure 17). A collapsing concrete headwall marks Drain 4's inlet on the inside corner of the road. A 12-inch clay tile directs water under the road and southward about 80 feet toward the lake. The second inlet to the drain is adjacent to the private driveway on the south side of the road with a grate covering the opening that is level with the yard. JFNew and others who have visited the site could not locate the outlet of this drain at the lake. This drain likely delivers small amounts of hydrocarbons, salt, and organic debris to the lake because the outlet is probably partially or fully blocked by previous seawall work. Leaves plugged Drain 4's inlet during the last inspection in the fall of 2002. The alternatives available to treat the stormwater issues at this site include: 1) doing nothing because there does not appear to be a sediment accumulation problem in the lake in this area and there have been no complaints; 2) installing a new headwall/catch basin structure and scheduling regular maintenance cleaning; 3) rebuilding the roadside swales and installing gravel/sand infiltration trenches to filter water before it reaches Drain 4.

JFNew recommends doing nothing at this time, as there are drains with more significant issues that need to be resolved. When Chapman Lake Drive is scheduled for repaving, it is suggested that this drainage system be reconstructed to include infiltration swales and an inlet catch basin that can be cleaned.

FIGURE 17. Main inlet to Drain 4.

Drain 5 originates in the northeast corner of County Road 400 North and Chapman Lake Drive intersection. The watershed draining to Drain 5 encompasses approximately 150 acres and includes a large wetland complex as well as the recently constructed residence at the southeast corner of the intersection. Drain 5 has two inlets: one in the woodlot northeast of the intersection and one in residential lawn on the north side of County Road 400 North. Water draining to these inlets is directed into a 6-inch clay tile. Once in the tile, water presumably flows in a southwesterly direction under the County Road 400 North/Chapman Lake Drive intersection and then under a residential garage and home before emptying to Chapman Lake through a concrete seawall (Figure 18). The tile has been consistently failing in the lawn near the lake due to increased hydraulic head pressure. Presumably the tile is undersized. Sinkholes created at the tile junctions release sediment into the tile. The sediment is ultimately discharged to Chapman Lake. Alternatives considered for treating stormwater issues at this site include: 1) installing a stormwater detention basin using a riser at the northeast corner of the County Road 400 North/Chapman Lake Drive intersection; 2) installing infiltration swales in the residential yard at the southeast corner of the intersection; and 3) replacing the entire tile system.

JFNew recommends creating the detention area to slow water delivery to the tile by installing a perforated riser pipe and replacement of the tile on the private property with larger diameter plastic drainage pipe. Creating the detention area would enhance the existing wetland and reduce sediment loads entering Drain 5. Replacing the tile would provide safety and aesthetic benefits for the residential property.

FIGURE 18. Drainage path for Drain 5. Presumably the drain exists as a tile that runs through the yard and underneath the resident's garage and home.

Drain 6 is a roadside drain located on the east side of Chapman Lake Drive approximately 400 feet south of County Road 400 North intersection. Drain 6 receives water from approximately 400 feet of Chapman Lake Drive. A 4-foot square concrete box structure surrounds Drain 6's inlet (Figure 19). Water entering the inlet structure is directed into a 24-inch metal culvert pipe. The pipe traverses residential land, carrying water about 150 feet directly to Chapman Lake. The drain carries an unknown amount of road salt, sediment, and hydrocarbons to the lake. The alternatives to treat stormwater in this drain include: 1) doing nothing; 2) installing a deeper catch basin structure that would trap sediment and debris and scheduling regular maintenance cleaning; 3) rebuilding the delivery swales to include gravel/sand infiltration trenches. JFNew recommends that the inlet structure be rebuilt with a functioning catch basin and pretreatment infiltration swales be installed when the county repaves Chapman Lake Drive.

FIGURE 19. Inlet structure for Drain 6.

The inlet to Drain 7 is located on the east edge of Chapman Lake Drive approximately 500 feet north of Crooked Creek. The drain's inlet consists of a steel grated 3-foot square concrete box structure (Figure 20). A 12-inch metal pipe carries water from the inlet to Chapman Lake. Surface runoff from about 300 feet of Chapman Lake Drive and a series of gravel driveways discharges into Drain 7. Drain 7 conveys a significant load of sediment to the lake as evidenced by the sediment accumulation in Chapman Lake near Drain 7's outlet. The alternatives to treat stormwater at this site include: 1) having property owners in the drainage basin pave their driveways to eliminate sediment originating from gravel drives; 2) installing a larger catch basin structure and scheduling regular maintenance cleaning; 3) installing gravel infiltration trenches in roadside swales; 4) creating a rain garden at the drain's inlet. JFNew recommends a combination of two treatments: creating roadside infiltration trenches and installing a rain garden infiltration system at the inlet.

FIGURE 20. Inlet to Drain 7.

The inlet to Drain 8 is located on the south side of Chapman Lake Drive, 300 feet west of the lake's public boat ramp. An open swale carries surface runoff to Drain 8's inlet. From the drain's inlet, a 24-inch metal pipe conveys water under the road and under open residential property (the neighborhood lake access area). Water from the pipe discharges into Chapman Lake through an opening in a concrete seawall approximately 60 feet from the drain's inlet (Figure 21). The pipe has discharged varying amounts of sediment over the years as evidenced by the sediment accumulation in the channel at the drain's discharge point. The drain also likely contributes road salts and hydrocarbons to the lake. The alternatives considered to treat stormwater at this site include: 1) doing nothing; 2) installing a permanent catch basin and scheduling regular maintenance cleaning; 3) reconstructing the road side swales as infiltration trenches; 4) constructing a small wetland treatment basin in the neighborhood access area to trap nutrients, hydrocarbons, and sediment that may enter the drain from the road. JFNew recommends constructing a small wetland treatment basin that is conceptually designed to treat nutrients, hydrocarbons, and sediment.

FIGURE 21. Drain 8 outlet at Chapman Lake.

Drain 9's inlet is located on the southwest corner of the intersection of County Road 325 East and Chapman Lake Drive. The natural earthen inlet area drains into an 18-inch culvert that carries water diagonally across the intersection approximately 75 feet to the lake (Figure 22). The path of the drain crosses under the road onto private property for about 30 feet before entering a neighborhood easement to a channel. The pipe discharges into the channel on the easement. The pipe has discharged varying amounts of sediment over the years as evidenced by the sediment accumulation the lake's channel at the discharge point. The drain also likely contributes road salts and hydrocarbons to the lake from the road. The alternatives considered to treat stormwater at this site include: 1) doing nothing; 2) installing a permanent catch basin and scheduling regular maintenance cleaning; 3) reconstructing the roadside swales as infiltration trenches; 4) constructing a small wetland treatment basin in the neighborhood access area to trap nutrients, hydrocarbons, and sediment that may enter the drain from the road. JFNew recommends constructing a small wetland treatment basin conceptually designed to treat nutrients, hydrocarbons, and sediment.

FIGURE 22. Drain 9 outlet at Chapman Lake.

3.3.2 Easement and Land Availability Determination

All of the inlets for the nine drains examined fall within the right-of-way of county roads. JFNew met with the Kosciusko County Highway Engineer (Rob Ladson) to discuss the problems these drains cause and potential solutions. Mr. Ladson agreed that the county is responsible for cleaning and maintaining all existing structural catch basins. These catch basins have not been cleaned in the past because they were never put on a maintenance schedule. The county commissioners have jurisdiction over all work in the right-of-way and the authority to regulate that work passes through the County Engineers Office and to the County Highway Department. Mr. Ladson stated that he would not support the installation of additional stormwater inlets that would require maintenance, as the crews cannot maintain the existing stormwater drainage system. Mr. Ladson did, however, support the idea of constructing infiltration trenches and grassed swales since these structures require less maintenance.

The proposed projects or portions of projects that are outside of the County right-of-way are on private property or community property (deeded neighborhood access lanes). JFNew wrote to and/or met with all the owners of these properties (Appendix B). To date all owners have agreed to the conceptual design drawings; however, no official agreements with these landowners were sought. Therefore, it is critical, that during any future design work, the owners be contacted and be allowed to review and approve final design work for proposed projects within their property limits.

3.3.3 Preliminary Design and Conceptual Drawings

JFNew has recommended modification to four of the nine drainage systems examined. The following paragraphs describe, in general terms, the concepts presented to the property owners. Included with each description is a conceptual sketch of how the project might look. These sketches are only conceptual in nature and not intended to serve as a formal design document. Projects must ultimately be designed to consider the volume of runoff from the drainage area, the needs of the property owners and County Highway Department, and the maintenance of the proposed structures or changes.

Drain 5, which has two inlets at the intersection of Chapman Lake Drive and County Road 400 North, is in need of reconstruction. Increasing amounts of runoff have overwhelmed the current tile system. Two steps to this reconstruction are proposed. The first step is to place a perforated riser on the open end of the six-inch tile at the drain’s inlet on the northeast corner of the Chapman Lake Drive/County Road 400 North intersection. This will increase the flooding on the existing wetland property but will reduce the rate at which storm flows enter the existing tile. By metering the water flow into the tile, it is possible that head pressure could be reduced enough to eliminate the “blow holes” that occur at the clay tile junctions. If that does not alleviate the problem it is suggested that the entire line from Chapman Lake to the intersection be replaced, increasing the size of the tile to handle a 50-100 year storm event. The new tile line will have to be routed around the existing home, which may sit on top of the existing tile (Figure 23).

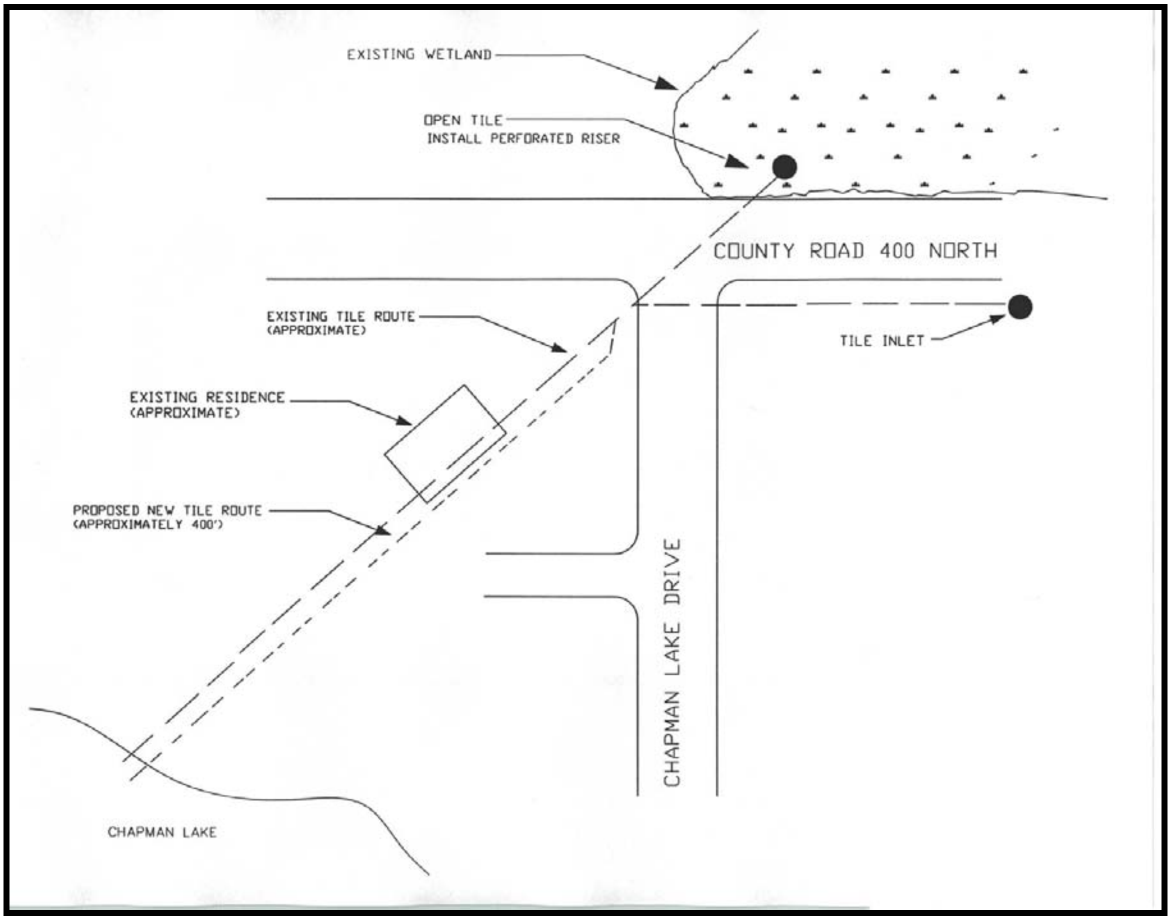

FIGURE 23. Existing and proposed infrastructure at Drain 5.

Drain 7 lies at the base of a driveway at 826 Chapman Lake Drive (Figure 24). JFNew proposes constructing a rain garden in place of the catchment basin in the county-right-of-way (Figure 25). In conjunction with the rain garden, roadside infiltration trenches should be established along the east side of Chapman Lake Drive from the top of the hill approximately 300 feet north of Drain 7's inlet to the proposed rain garden. The infiltration trenches should consist of a pea gravel-filled trench approximately one foot wide and two feet deep. The trench should connect with the vegetated rain garden in place of the existing 12" plastic drainpipe. The infiltration trench would be blended into the existing gravel driveways. The proposed rain garden would consist of a pea-gravel filled concrete box set on top of the existing drain inlet at the same grade as the adjacent driveway. No change would be made in how the water exits the existing inlet area. The top of the rain garden would be planted with native forbs and/or grasses.

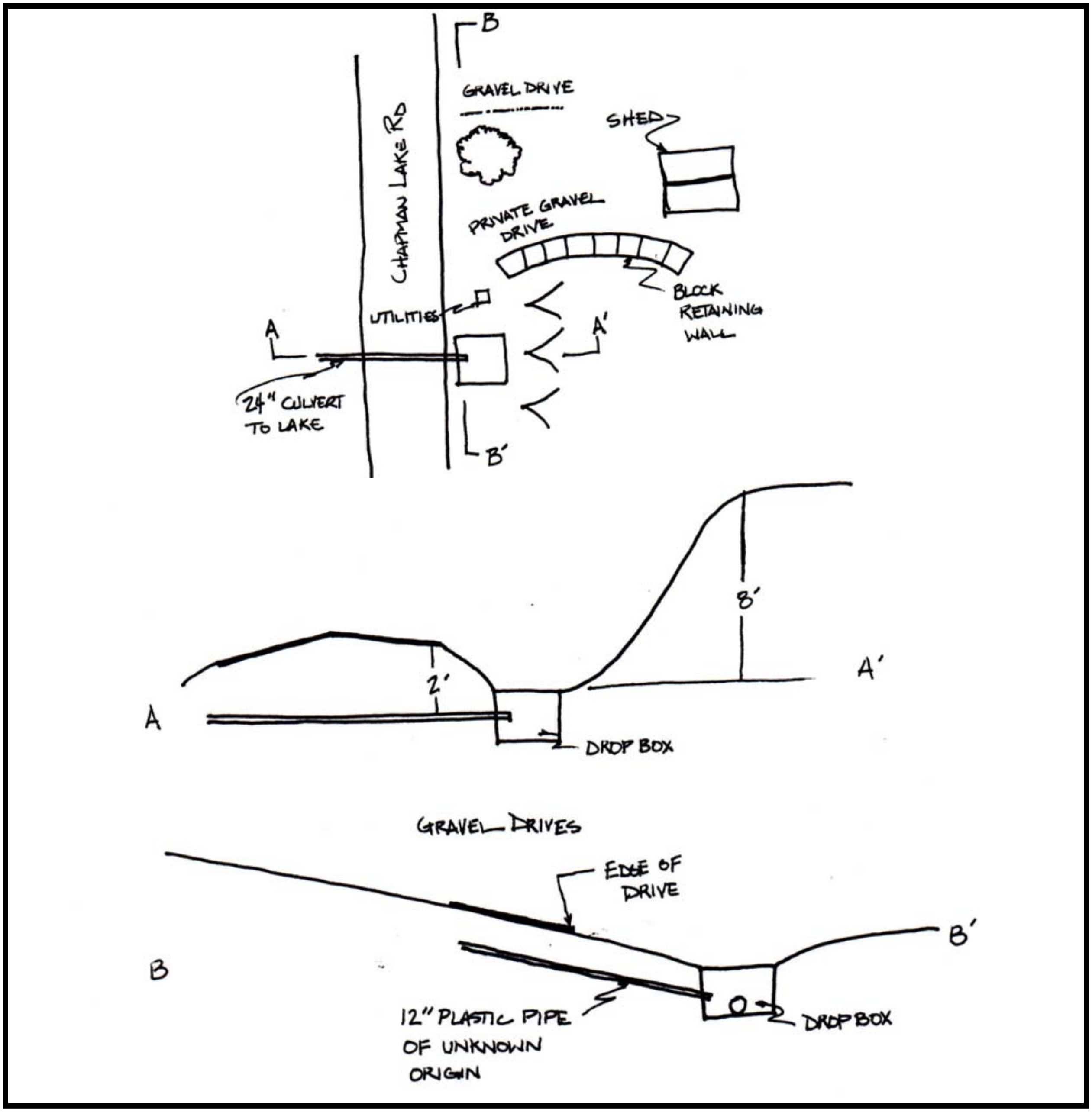

FIGURE 24. Current drain infrastructure for Drain 7.

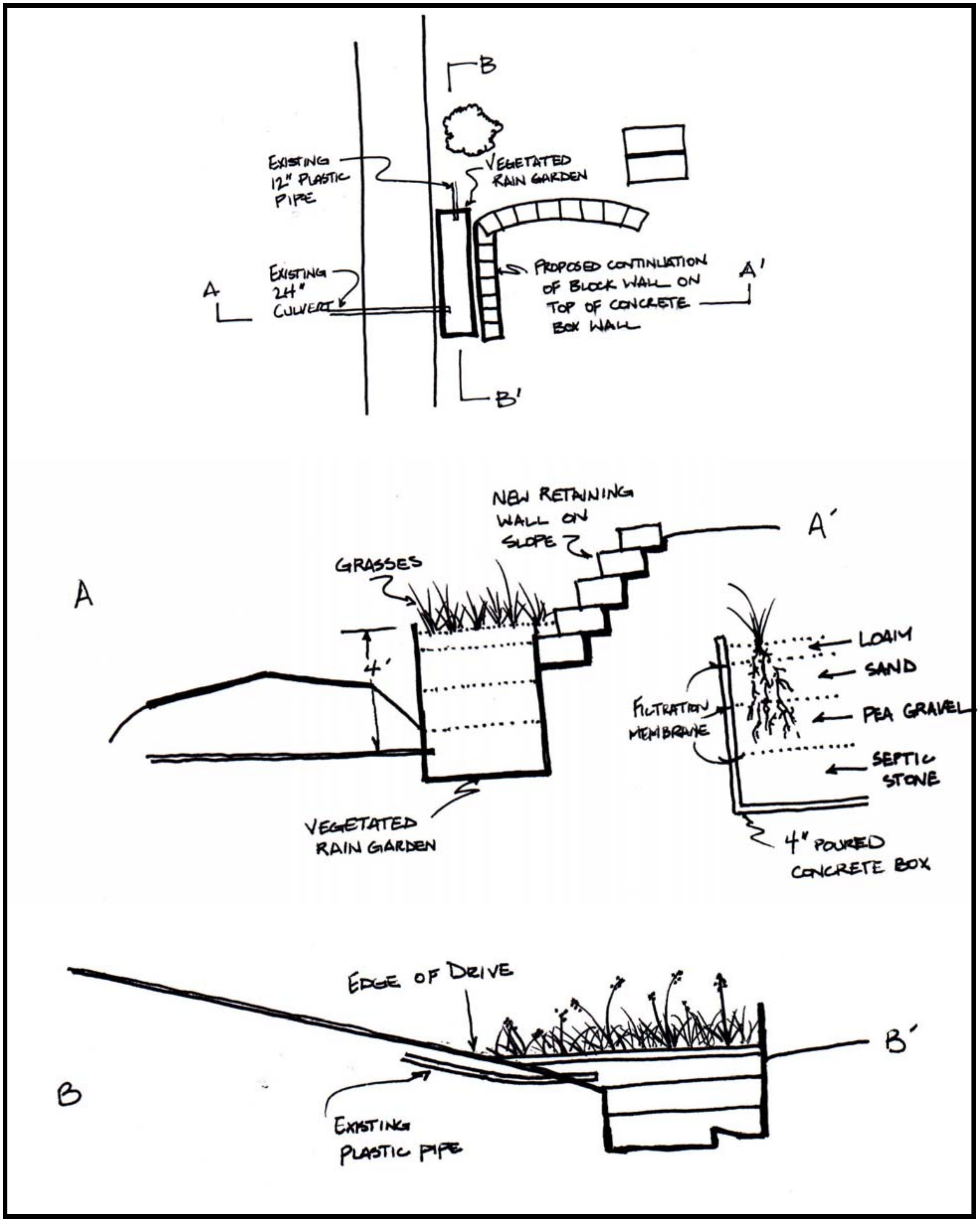

FIGURE 25. Proposed rain garden infrastructure for Drain 7.

Drain 8 empties into a channel off Big Chapman Lake just west of the public boat launch (Figure 21; Figure 26). JFNew recommends the installation of a small treatment wetland on the 75-foot wide access easement at the head of the channel (Figure 21). The treatment wetland as proposed would intercept the existing 24-inch metal pipe approximately 10 feet from Chapman Lake Drive (Figure 27). A 15-foot diameter pool approximately three feet deep would be excavated at the new outlet of the pipe. The pool would serve as a sediment trap to reduce sediment loading to the lake. The next section of proposed treatment wetland would be a shallow swale extending approximately 40 feet from the pool. The swale would be vegetated with common sedges or rushes to absorb pollutants that passed through the pool. The final step in the treatment would be a gravel or rock chute extending down toward the water surface in the lake channel or into the existing culvert pipe which exits through the seawall. This treatment wetland would remove from 60 to 90 % of the solids and associated pollutants from the stormwater entering the lake at this point. Cleaning the lake channel to its original depth and establishing a vegetated buffer between the discharge point and the end of the channel could gain additional treatment.

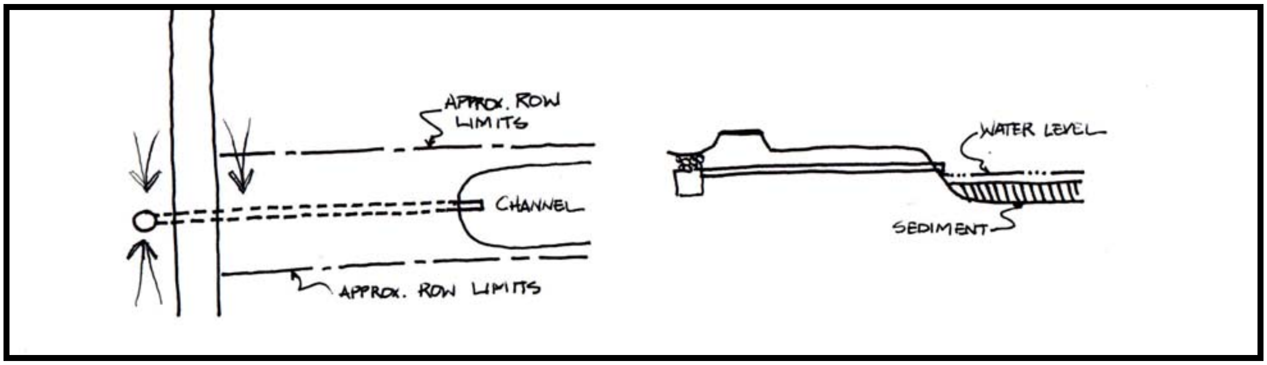

FIGURE 26. Existing drain infrastructure located at Drain 8.

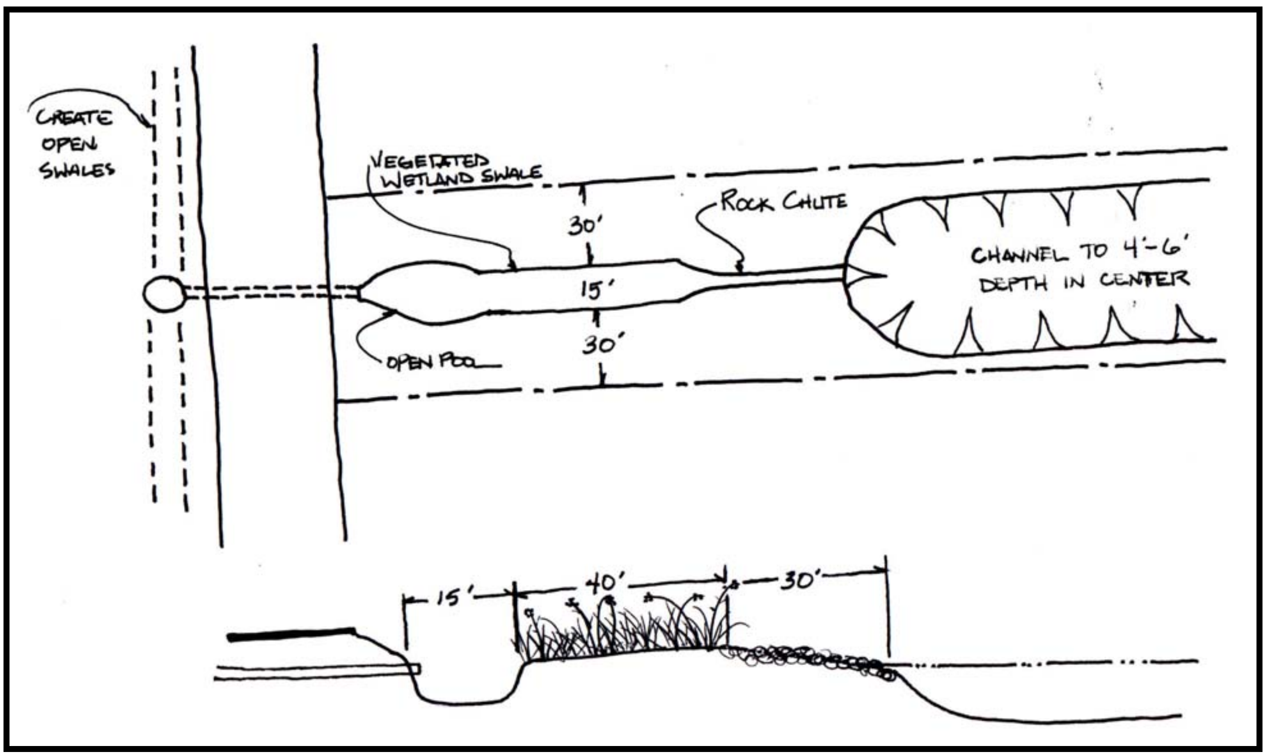

FIGURE 27. Proposed wetland swale for Drain 8.

Drain 9 empties into a channel off Big Chapman Lake at the intersection of County Road 325 East and Chapman Lake Drive (Figure 22; Figure 28). JFNew recommends installing a small treatment wetland on the 75-foot wide access easement near the channel (Figure 29). The treatment wetland as proposed would intercept the existing 18-inch metal pipe approximately 40 feet from the Chapman Lake Drive within the public access easement. A 20-foot diameter pool approximately three feet deep would be excavated at the new outlet of the pipe. The pool would trap sediment, reducing sediment loads to the lake. The next section of proposed treatment would be a shallow swale approximately 30 feet long. The swale would be vegetated with common sedges or rushes to absorb pollutants that passed through the pool. The final step in the treatment would be a gravel or rock chute extending to the water surface in the lake channel. This treatment wetland would remove from 60 to 90% of the solids and associated pollutants from the stormwater entering the lake at this point. Cleaning the existing channel to its original depth and establishing a vegetated buffer at the final outlet of the rock chute could gain additional treatment.

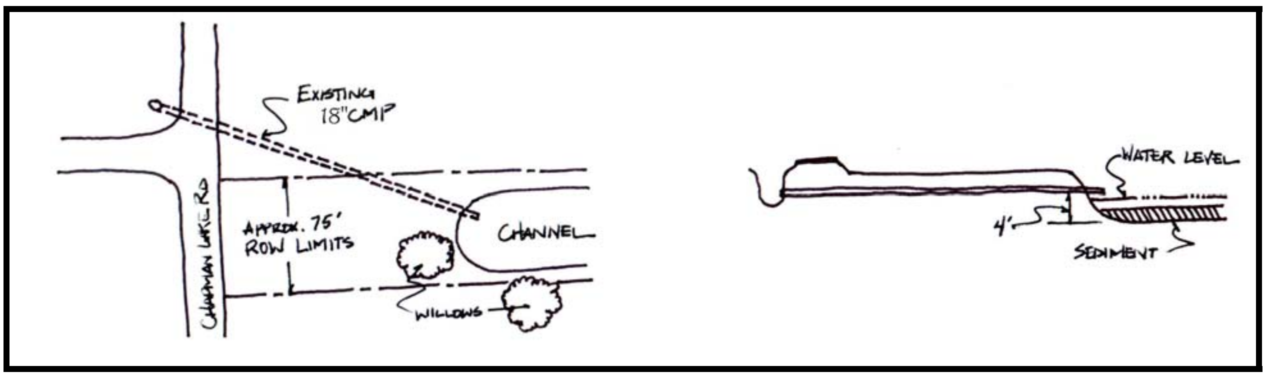

FIGURE 28. Existing drain infrastructure located at Drain 9.

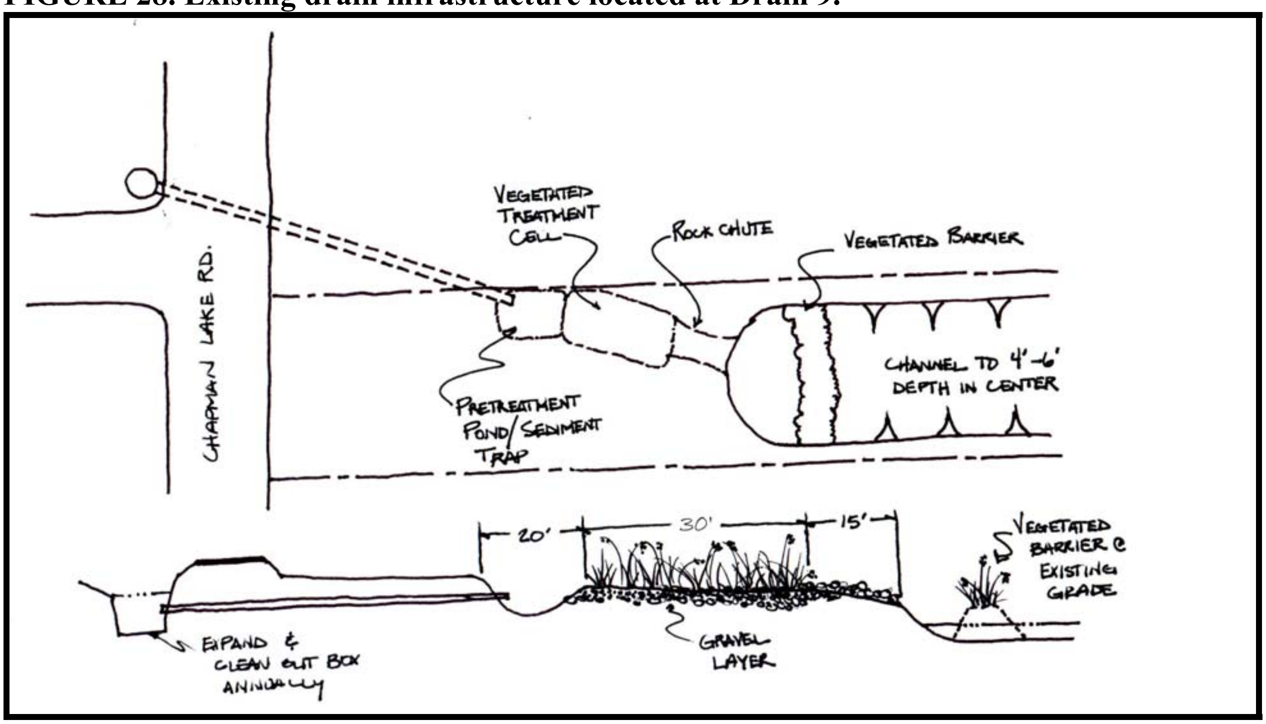

FIGURE 29. Proposed wetland swale for Drain 9.

3.3.4 Permit Requirements

Projects associated with the storm drains will require permits from the Kosciusko County Highway Department as they are proposed to occur within the county right-of-way. State or federal permits are not required for the above work unless channel dredging is included as a portion of the work. Channel dredging would require a Section 404 Permit from the US Army Corps of Engineers, a Section 401 Water Quality Certification from the Indiana Department of Environmental Management, and a Lake Permit from the Indiana Department of Natural Resources-Division of Water.

3.3.5 Landowner Agreements

As stated earlier no formal written agreements were established with landowners regarding the proposed storm drain projects. Conceptual plans were presented to the owners and the owners did not express any objection to the concepts (Appendix B). Further design will be necessary before the homeowners are asked to sign official agreements with the Chapman Lakes Foundation for the proposed work.

3.3.6 Environmental Impact Assessment

The storm drains and their proposed retrofits are all within maintained residential lawn areas or roadside swales. No wetlands exist within the proposed project sites with the exception of the proposed project on Drain 5 at the northeast corner of County Road 400 North and Chapman Lake Drive. The drainage tile that currently drains this wetland impairs its hydrological functioning. The proposed riser is expected to enhance the wetland's hydrology, restoring some of its functionality. An endangered, rare, and threatened species database search was conducted for the diagnostic study and no species of concern were found in the vicinity of the project sites.

3.3.7 Unusual Physical and Social Costs

The main unusual social and physical costs associated with the storm drain projects would be the cost of working with the interested parties to obtain aesthetically appealing projects while still serving the function intended. Negotiations with the landowner to install a project may result in additional work not thought of in this feasibility study. The permanent loss of land use in the areas of the wetland filters or for the increased hydro-period with the installed riser may result in landowner compensation issues which were not addressed in this study.

3.3.8 Opinion of Probable Cost and Proposed Time Line

The following costs estimates are based on similar projects that have been completed and may or may not represent local contractor pricing. They are put forth only to assist the landowner or other interested party in obtaining funding for the proposed projects. JFNew does not assume liability if contractor estimates are significantly higher or lower than the estimates given.

The probable cost for replacing the existing tile and adding a riser to the inlet of Drain 5 at the corner of County Road 400 North and Chapman Lake Drive is approximately $2,100. The above figure is arrived at by adding the cost of the tile replacement ($5.00 a lineal foot for 400 feet of 8-inch tile) to the cost of perforated riser installation ($100). This project would likely take from two-three days to install and should be completed during the dry season. This estimate does not include any engineering services required to calculate pipe size or additional utility work that may be required.

The proposed project at Drain 7, installation of an infiltration trench and rain garden, requires engineering and construction services. It is estimated that the trench will cost approximately $5.00 per foot and the rain garden will cost approximately $4,500 to install, for a total of $6,000. Engineering costs for a full set of plans and specifications may double the cost of the project. This project would likely take one week to install.

The proposed project for Drain 8 will require a set of plans and specifications before construction. Assuming the plans include limited survey work, they will cost approximately $3,000-$6,000. Construction will likely cost approximately $4,000. If channel dredging were part of the plans, the estimated cost of the project would increase by about $12,000. Additionally, a location for the disposal of the dredge spoils would be required. If dredging the lake channel is not part of the project, federal or state permits are not required and construction can begin immediately following plan approval. The project should take less than one week to complete if channel dredging is not a part of the project.

The proposed project for Drain 9 will require a set of plans and specifications before construction. Assuming the plans include limited survey work, they will cost approximately $3,000-$6,000. Construction will likely cost approximately $4,000. If channel dredging were part of the plans the estimated cost of the project would increase by about $12,000. If dredging the lake channel is not part of the project, federal or state permits are not required and construction can begin immediately following plan approval. The project should take less than one week to complete if channel dredging is not a part of the project.

The opinion of probable cost is $46,100-$52,100 for tile replacement, infiltration trench construction, and wetland treatment construction at the four drains (Table 10). These costs include channel dredging at both Drain 8 and Drain 9. If dredging is not included as a portion of the work, then the projects will cost approximately $22,100-$28,100.

TABLE 10. Opinion of probable cost for the four drain projects.

Drain	Project Description	Cost
Drain 5	Replacing existing tile and adding tile riser	$2,100
Drain 7	Installing infiltration trench and rain garden	$6,000
Drain 8	Plans and specifications (including survey work)	$3,000-$6,000
	Constructing a treatment wetland	$4,000
	Channel dredging	$12,000
Drain 9	Plans and specifications (including survey work)	$3,000-$6,000
	Constructing a treatment wetland	$4,000
	Channel dredging	$12,000
	Total Cost	**$46,100-$52,100**

3.3.9 Project Justification

The storm drains were not sampled for pollutant export; therefore only limited conclusions can be drawn on the amount of pollutants that these drains are delivering to the Chapman Lakes and what function the proposed solutions will have. Road salts, nutrients from adjacent lawns and leaf litter, and hydrocarbons are going directly to the lakes as they are washed from the roads.

Justification for the projects comes mainly from complaints of sediment build-up at the drain outlets in the lake and general knowledge of sediment and nutrient removal from other projects across the nation. Properly maintained catch basins have been found to remove 32-97% of total suspended solids (Pitt et al., 2000; Mineart and Singh, 1994). Wetland filters have been found to remove between 40-90% of hydrocarbons, nutrients and sediment from runoff (Mustafa, 1997; Wang and Mitsch, 1996; Warwich et al., 1998). Projects vary in efficiency due to size and type of construction as well as the age of filters. Mature wetland filters absorb fewer pollutants than newly constructed filters. This study assumes that the storm drains around the lake play a minor role in the delivery of pollutants to the lakes. However, the drains are contributing pollutants and the cost of treatment is relatively low compared to some of the other issues, therefore treatment is recommended.

4.0 RECOMMENDATIONS

1) Apply for a LARE grant in 2002 for design and construction of recommended bank and channel stabilization projects along Crooked Creek and its tributary. Begin construction of the projects while the Greystone Development parcel is still under construction.

2) Apply for a LARE design-build grant in January of 2003 for the grade control and bank stabilization along Arrowhead Drain. Begin design work in the fall of 2003 and construction in the summer of 2004.

3) Continue a dialog with the Kosciusko County Engineer to encourage the maintenance of existing catch basins identified. Work with the landowner of Drain 3 to correct the issue immediately using Foundation funding if necessary. Apply for local grants in 2003-4 for the four drain retrofits identified. The priority of retrofitting additional drains should be numbers 5, 7, 9, and 8 in order.

4) Establish a dialog with the Soil and Water Conservation District (SWCD) office and the landowners of various parcels where BMPs and wetland restoration were recommended during the diagnostic study. Most of the potential project areas were located within the Crooked and Lozier's Creek Subbasins. A long-term, trusting relationship with these landowners may result in conservation and/or restoration project implementation.

5) Once external nutrient loading has been controlled, re-evaluate lake chemistry and condition to determine if any in-lake treatments are necessary. Applications for dredging permits may also be submitted at this time.

6) Pursue funding to address various other diagnostic study recommendations including: lake resident education, sanitary sewer installation, watershed management plan development, and aquatic plant management plan development.

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APPENDIX A

Stream photos along the Mainstem of Crooked Creek and Arrowhead Drain

CHAPMAN LAKES ENGINEERING FEASIBILITY STUDY
KOSCIUSKO COUNTY, INDIANA

Bank Erosion Photographs along Arrowhead Drain
Chapman Lake Engineering Feasibility Report
Arrowhead Drain Project
Kosciusko County, Indiana

JFNA# 99-04-01-02

Bank Erosion Photographs along the Mainstem of Crooked Creek
Chapman Lake Engineering Feasibility Report
Crooked Creek Project
Kosciusko County, Indiana

JFNA# 99-04-01-02

APPENDIX B

Communication with Property Owners

CHAPMAN LAKES ENGINEERING FEASIBILITY STUDY
KOSCIUSKO COUNTY, INDIANA

Communication with Property Owners

Property owners were consulted throughout the process of completing this Feasibility Study. Communication from these individuals is not included in this file, but is available from the Indiana Department of Natural Resources Lake and River Enhancement Program Office or from JFNew.

APPENDIX C

Communication with Agencies

CHAPMAN LAKES FEASIBILITY STUDY
KOSCIUSKO COUNTY, INDIANA

Communication with Agencies

Regional and state agencies were consulted throughout the process of completing this Feasibility Study. Communication from these individuals is not included in this file, but is available from the Indiana Department of Natural Resources Lake and River Enhancement Program Office or from JFNew.

APPENDIX D

Biotic Assessment Field Datasheets

CHAPMAN LAKES FEASIBILITY STUDY
KOSCIUSKO COUNTY, INDIANA

STREAM: Crooked Creek **RIVER MILE:** ______ **DATE:** 4/25/2002 **QHEI SCORE** 78

1) SUBSTRATE: (Check ONLY Two Substrate Type Boxes: Check all types present)

SUBSTRATE SCORE 18

TYPE			POOL	RIFFLE
		BLDER/SLAB(10)	x	x
		BOULDER(9)		
	x	COBBLE(8)		
		HARDPAN(4)		
		MUCK/SILT(2)	x	

TYPE			POOL	RIFFLE
		GRAVEL(7)		
		SAND(6)	x	x
		BEDROCK(5)		
		DETRITUS(3)		
		ARTIFIC(0)		

SUBSTRATE ORIGIN (all)

	LIMESTONE(1)		RIP/RAP(0)
x	TILLS(1)		HARDPAN(0)
	SANDSTONE(0)		
	SHALE(-1)		
	COAL FINES(-2)		

SILT COVER (one)

	SILT-HEAVY(-2)		SILT-MOD(-1)
x	SILT-NORM(0)		SILT-FREE(1)

Extent of Embeddedness (check one)

	EXTENSIVE(-2)		MODERATE(-1)
x	LOW(0)		NONE(1)

TOTAL NUMBER OF SUBSTRATE TYPES: x >4(2) <4(0)

NOTE: (Ignore sludge that originates from point sources: score is based on natural substrates)

COMMENTS:

2) INSTREAM COVER:

COVER SCORE 12

TYPE (Check all that apply)

	UNDERCUT BANKS(1)		DEEP POOLS(2)		OXBOWS(1)
x	OVERHANGING VEGETATION(1)	X	ROOTWADS(1)		AQUATIC MACROPHYTES(1)
x	SHALLOWS (IN SLOW WATER)(1)	X	BOULDERS(1)	X	LOGS OR WOODY DEBRIS(1)

AMOUNT (Check only one or Check 2 and AVERAGE)

	EXTENSIVE >75%(11)
X	MODERATE 25-75%(7)
	SPARSE 5-25%(3)
	NEARLY ABSENT <5%(1)

COMMENTS:

3) CHANNEL MORPHOLOGY: (Check ONLY ONE per Category or Check 2 and AVERAGE)

CHANNEL SCORE 18

SINUOSITY		DEVELOPMENT		CHANNELIZATION		STABILITY	
x	HIGH(4)		EXCELLENT(7)	X	NONE(6)	X	HIGH(3)
	MODERATE(3)	X	GOOD(5)		RECOVERED(4)		MODERATE(2)
	LOW(2)		FAIR(3)		RECOVERING(3)		LOW(1)
	NONE(1)		POOR(1)		RECENT OR NO RECOVERY(1)		

MODIFICATION/OTHER

X	SNAGGING		IMPOUND
	RELOCATION		ISLAND
	CANOPY REMOVAL		LEVEED
	DREDGING		BANK SHAPING
	ONE SIDE CHANNEL MODIFICATION		

COMMENTS:

4) RIPARIAN ZONE AND BANK EROSION: (Check ONE box or Check 2 and AVERAGE per bank)

RIPARIAN SCORE 10

River Right Looking Downstream

RIPARIAN WIDTH (per bank)

L	R	(per bank)
x	X	WIDE >150 ft.(4)
		MODERATE 30-150 ft.(3)
		NARROW 15-30 ft.(2)
		VERY NARROW 3-15 ft.(1)
		NONE(0)

EROSION/RUNOFF-FLOODPLAIN QUALITY

L	R	(most predominant per bank)	L	R	(per bank)
X	X	FOREST, SWAMP(3)			URBAN OR INDUSTRIAL(0)
		OPEN PASTURE/ROW CROP(0)			SHRUB OR OLD FIELD(2)
		RESID.,PARK,NEW FIELD(1)			CONSERV. TILLAGE(1)
		FENCED PASTURE(1)			MINING/CONSTRUCTION(0)

BANK EROSION

L	R	(per bank)
X	X	NONE OR LITTLE(3)
		MODERATE(2)
		HEAVY OR SEVERE(1)

COMMENTS:

5) POOL/GLIDE AND RIFFLE/RUN QUALITY

NO POOL = 0 **POOL SCORE** 5

MAX.DEPTH (Check 1)

	>4 ft.(6)
	2.4-4 ft.(4)
x	1.2-2.4 ft.(2)
	<1.2 ft.(1)
	<0.6 ft.(Pool=0)(0)

MORPHOLOGY (Check 1)

X	POOL WIDTH>RIFFLE WIDTH(2)
	POOL WIDTH=RIFFLE WIDTH(1)
	POOL WIDTH<RIFFLE WIDTH(0)

POOL/RUN/RIFFLE CURRENT VELOCITY (Check all that Apply)

	TORRENTIAL(-1)		EDDIES(1)
	FAST(1)		INTERSTITIAL(-1)
X	MODERATE(1)		INTERMITTENT(-2)
	SLOW(1)		

COMMENTS:

RIFFLE SCORE 5

RIFFLE/RUN DEPTH

	GENERALLY >4 in. MAX.>20 in.(4)
	GENERALLY >4 in. MAX.<20 in.(3)
x	GENERALLY 2-4 in.(1)
	GENERALLY <2 in.(Riffle=0)(0)

RIFFLE/RUN SUBSTRATE

X	STABLE (e.g., Cobble,Boulder)(2)
	MOD.STABLE (e.g., Pea Gravel)(1)
	UNSTABLE (Gravel, Sand)(0)
	NO RIFFLE(0)

RIFFLE/RUN EMBEDDEDNESS

	EXTENSIVE(-1)	X	NONE(2)
	MODERATE(0)		NO RIFFLE(0)
	LOW(1)		

COMMENTS:

6) GRADIENT (FEET/MILE): 26.4

% POOL 20% **% RIFFLE** 70% **% RUN** 10% **GRADIENT SCORE** 10

J.F. New & Associates, Inc.
Aquatics Division
FISH POPULATION ANALYSIS
(Condition factor & Length-Frequency Summary)

STREAM/LOCATION Crooked Creek

PROJECT # 99-04-01/02

COLLECTION DATE: 4/26/02

SPECIES (common name or code)	NUMBER	LENGTH or RANGE (mm)	WEIGHT (grams)	DISEASE	COMMENTS
Longear sunfish	7	80-120	-	-	-
Blacknose dace	27	45-85	-	-	-
Creek chub	7	65-185	-	-	-
Logperch	20	65-110	-	-	-
	61				

Number of Species: 4 Sampling Time Involved: 17.1 (min) Method of Collection: Backpack

Biologist(s): SZ, CS Date of Report: 5-1-02

J.F. New & Associates, Inc
Aquatics Unit
FISH NUMBER AND LENGTH FIELD DATA SHEET

STREAM/LOCATION: Crooked Creek PROJECT # 99-04-01/02

DATE: 26 Apr 02 RUN 1 of 1 TIME: 1026 sec (min:sec)

METHOD: backpack LENGTH: 200 (ft) 6; 12; 13'
avg width = 10.1

Species

Longear Sunfish Number	Longear Sunfish Length	Blacknose Dace Number	Blacknose Dace Length	Creek Chub Number	Creek Chub Length	Logperch Number	Logperch Length	Number	Length
1	100	1	85	1	102	preserved 1	80		
1	120	1	65	1	175	1	90		
1	96	1	45	1	185	1	85		
1	85	1	42	1	65	1	110		
1	95	1	40	1	130	1	80		
1	90	1	76	1	122	1	85		
1	80	1	80	1	115	1	90		
		8	45-80			5	70-100		
		1	81			7	65-90		
		1	66			1	80		
		1	30						

Species

Number	Length	Blacknose Dace Number	Blacknose Dace Length	Number	Length	Number	Length	Number	Length
		1	75						
		1	80						
		6	65-82						
		1	72						

J.F. New & Associates, Inc.
Aquatics Unit
IBI CALCULATION
(< 20 miles^2 drainage (Headwater Stream))
Eastern Cornbelt Plain

STREAM/LOCATION: Crooked Creek

DRAINAGE AREA (mile^2): 1.2

PROJECT #: 99-04-01/02

COLLECTION DATE: 4/26/02

Metric	# or %	Score
# of Species	4	3
# of DMS sp.	1	5
% Headwater sp.	44.3	5
# Minnow sp.	2	5
# of Sensitive sp.	2	5
% Tolerant Individuals	55.7	1
% Omnivore Individuals	0	5
% Insectivores Individuals	44.3	3
% Pioneer sp.	11.5	5
Catch per Unit Effort	61	3
% Simple Lithophils Individuals	77	5
% DELT Individuals	0	5

Sample Distance (ft or m)	200
Sample Time (sec or min)	1026
Sample Method	Backpack
IBI Score	50
Integrity Class	Good

STREAM: Arrowhead Drain **RIVER MILE:** ______ **DATE:** 4/25/2002 **QHEI SCORE** 50

1) SUBSTRATE: (Check ONLY Two Substrate Type Boxes: Check all types present) **SUBSTRATE SCORE** 13

TYPE			POOL	RIFFLE				POOL	RIFFLE
[ ]	[ ]	BLDER/SLAB(10)			[ ]	[ ]	GRAVEL(7)		
[ ]	[ ]	BOULDER(9)			[ ]	[ ]	SAND(6)		
[ ]	[ ]	COBBLE(8)			[ ]	[ ]	BEDROCK(5)		
[ ]	[ ]	HARDPAN(4)		x	[ ]	[ ]	DETRITUS(3)		
[ ]	[ ]	MUCK/SILT(2)		x	[ ]	[ ]	ARTIFIC(0)		

TOTAL NUMBER OF SUBSTRATE TYPES: [ ] >4(2) [x] <4(0)

SUBSTRATE ORIGIN (all)
- [ ] LIMESTONE(1)
- [x] TILLS(1)
- [ ] SANDSTONE(0)
- [ ] SHALE(-1)
- [ ] COAL FINES(-2)
- [ ] RIP/RAP(0)
- [ ] HARDPAN(0)

SILT COVER (one)
- [ ] SILT-HEAVY(-2)
- [x] SILT-NORM(0)
- [ ] SILT-MOD(-1)
- [ ] SILT-FREE(1)

Extent of Embeddedness (check one)
- [ ] EXTENSIVE(-2)
- [x] LOW(0)
- [ ] MODERATE(-1)
- [ ] NONE(1)

NOTE: (Ignore sludge that originates from point sources: score is based on natural substrates)

COMMENTS: ______

2) INSTREAM COVER: **COVER SCORE** 6

TYPE (Check all that apply)
- [ ] UNDERCUT BANKS(1)
- [x] OVERHANGING VEGETATION(1)
- [ ] SHALLOWS (IN SLOW WATER)(1)
- [ ] DEEP POOLS(2)
- [x] ROOTWADS(1)
- [ ] BOULDERS(1)
- [ ] OXBOWS(1)
- [ ] AQUATIC MACROPHYTES(1)
- [x] LOGS OR WOODY DEBRIS(1)

AMOUNT (Check only one or Check 2 and AVERAGE)
- [ ] EXTENSIVE >75%(11)
- [ ] MODERATE 25-75%(7)
- [x] SPARSE 5-25%(3)
- [ ] NEARLY ABSENT <5%(1)

COMMENTS: ______

3) CHANNEL MORPHOLOGY: (Check ONLY ONE per Category or Check 2 and AVERAGE) **CHANNEL SCORE** 9

SINUOSITY
- [ ] HIGH(4)
- [ ] MODERATE(3)
- [x] LOW(2)
- [ ] NONE(1)

DEVELOPMENT
- [ ] EXCELLENT(7)
- [ ] GOOD(5)
- [x] FAIR(3)
- [ ] POOR(1)

CHANNELIZATION
- [ ] NONE(6)
- [ ] RECOVERED(4)
- [x] RECOVERING(3)
- [ ] RECENT OR NO RECOVERY(1)

STABILITY
- [ ] HIGH(3)
- [ ] MODERATE(2)
- [x] LOW(1)

MODIFICATION/OTHER
- [ ] SNAGGING
- [ ] RELOCATION
- [ ] CANOPY REMOVAL
- [x] DREDGING
- [ ] ONE SIDE CHANNEL MODIFICATION
- [ ] IMPOUND
- [ ] ISLAND
- [ ] LEVEED
- [ ] BANK SHAPING

COMMENTS: ______

4) RIPARIAN ZONE AND BANK EROSION: (Check ONE box or Check 2 and AVERAGE per bank) **RIPARIAN SCORE** 9

River Right Looking Downstream

RIPARIAN WIDTH (per bank)

L	R	(per bank)
x	x	WIDE >150 ft.(4)
		MODERATE 30-150 ft.(3)
		NARROW 15-30 ft.(2)
		VERY NARROW 3-15 ft.(1)
		NONE(0)

EROSION/RUNOFF-FLOODPLAIN QUALITY

L	R	(most predominant per bank)	L	R	(per bank)
x	x	FOREST, SWAMP(3)			URBAN OR INDUSTRIAL(0)
		OPEN PASTURE/ROW CROP(0)			SHRUB OR OLD FIELD(2)
		RESID.,PARK,NEW FIELD(1)			CONSERV. TILLAGE(1)
		FENCED PASTURE(1)			MINING/CONSTRUCTION(0)

BANK EROSION

L	R	(per bank)
		NONE OR LITTLE(3)
x	x	MODERATE(2)
		HEAVY OR SEVERE(1)

COMMENTS: ______

5) POOL/GLIDE AND RIFFLE/RUN QUALITY **NO POOL = 0** **POOL SCORE** 3

MAX.DEPTH (Check 1)
- [ ] >4 ft.(6)
- [ ] 2.4-4 ft.(4)
- [ ] 1.2-2.4 ft.(2)
- [x] <1.2 ft.(1)
- [ ] <0.6 ft.(Pool=0)(0)

MORPHOLOGY (Check 1)
- [ ] POOL WIDTH>RIFFLE WIDTH(2)
- [x] POOL WIDTH=RIFFLE WIDTH(1)
- [ ] POOL WIDTH<RIFFLE WIDTH(0)

POOL/RUN/RIFFLE CURRENT VELOCITY (Check all that Apply)
- [ ] TORRENTIAL(-1)
- [ ] FAST(1)
- [x] MODERATE(1)
- [ ] SLOW(1)
- [ ] EDDIES(1)
- [ ] INTERSTITIAL(-1)
- [ ] INTERMITTENT(-2)

COMMENTS: ______

RIFFLE SCORE 2

RIFFLE/RUN DEPTH
- [ ] GENERALLY >4 in. MAX.>20 in.(4)
- [ ] GENERALLY >4 in. MAX.<20 in.(3)
- [x] GENERALLY 2-4 in.(1)
- [ ] GENERALLY <2 in.(Riffle=0)(0)

RIFFLE/RUN SUBSTRATE
- [ ] STABLE (e.g., Cobble,Boulder)(2)
- [ ] MOD.STABLE (e.g., Pea Gravel)(1)
- [x] UNSTABLE (Gravel, Sand)(0)
- [ ] NO RIFFLE(0)

RIFFLE/RUN EMBEDDEDNESS
- [ ] EXTENSIVE(-1)
- [ ] MODERATE(0)
- [x] LOW(1)
- [ ] NONE(2)
- [ ] NO RIFFLE(0)

COMMENTS: ______

6) GRADIENT (FEET/MILE): 44 **% POOL** 5% **% RIFFLE** 20% **% RUN** 75% **GRADIENT SCORE** 8

J.F. New & Associates, Inc.
Aquatics Division
FISH POPULATION ANALYSIS
(Condition factor & Length-Frequency Summary)

STREAM/LOCATION Arrowhead Drain

PROJECT # 99-04-01/02

COLLECTION DATE: 4/26/02

SPECIES (common name or code)	NUMBER	LENGTH or RANGE (mm)	WEIGHT (grams)	DISEASE	COMMENTS
Logperch	21	70-100	-	-	-
Blacknose dace	4	50-65	-	-	-
Johnny darter	1	70	-	-	-
Creek chub	1	122	-	-	-
Emerald shiner	12	20-60	-	-	-
	39				

Number of Species: 5 Sampling Time Involved: 8.9 (min) Method of Collection: Backpack

Biologist(s): SZ, CS Date of Report: 5/1/02

J.F. New & Associates, Inc
Aquatics Unit
FISH NUMBER AND LENGTH
FIELD DATA SHEET

STREAM/LOCATION Arrowhead Drain PROJECT # 99-04-01/02

DATE: 26 Apr 02 RUN 1 of 1 TIME: 535 sec (min:sec)

METHOD: backpack LENGTH: 220 (ft) 4.5, 4, 5.5 width = 4.6

Species log perch		blacknose dace		creek chub		emerald shiner		johnny darter	
Number	Length	Number	Length	Number	Length	Number	Length	Number	Length
1	80	1	65	1	122	1	60	1	70
1	75	1	62			1	30		
1	90	1	60			1	23		
1	80	1	50			1	35		
1	70					1	30		
1	96					1	32		
1	76					1	25		
1	72					1	20		
1	84					1	25		
1	80					4			
1	85								

Species logperch									
Number	Length	Number	Length	Number	Length	Number	Length	Number	Length
1	85								
1	85								
1	70								
1	72								
1	90								
1	80								
1	75								
1	100								
1	80								
1	72								

J.F. New & Associates, Inc.
Aquatics Unit
IBI CALCULATION
(< 20 miles^2 drainage (Headwater Stream))
Eastern Cornbelt Plain

STREAM/LOCATION: Arrowhead Drain

DRAINAGE AREA (mile^2): 0.47

PROJECT #: 99-04-01/02

COLLECTION DATE: 4/26/02

Metric	# or %	Score
# of Species	5	3
# of DMS sp.	2	5
% Headwater sp.	10.3	5
# Minnow sp.	3	5
# of Sensitive sp.	1	5
% Tolerant Individuals	2.6	5
% Omnivore Individuals	< 50 Indiv.	1
% Insectivores Individuals	< 50 Indiv	1
% Pioneer sp.	5.1	5
Catch per Unit Effort	39	3
% Simple Lithophils Individuals	< 50 Indiv.	1
% DELT Individuals	< 50 Indiv.	1

Sample Distance (ft or m)	220
Sample Time (sec or min)	535
Sample Method	Backpack
IBI Score	40
Integrity Class	Fair